Sandia National Laboratories
Facilities Design Standards Manual

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Acronyms, Abbreviations, and Key Terms

AASHTO	American Association of State Highway and Transportation Officials
A/E	Architect/Engineer
AFFF	Aqueous Film Forming Foam
AMAFCA	Albuquerque Metropolitan Arroyo Flood Control Authority
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASCII	American Standard Code for Information Interchange
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning
ASME	American Society of Mechanical Engineers
AWWA	American Water Works Association
BFP	Back Flow Prevention
CADD	Computer-Aided Drafting and Design
CAS	Central Alarm System
CDR	Conceptual Design Report
CF	Compact Fluorescent
CFR	Code of Federal Regulations
CME	Construction Management Engineer
CPT	control power transformer
CPU	Central Processing Unit
CRI	Color Rendition Index
CSI	Construction Specifications Institute
CT	Current Transformer
DACR	Digital Alarm Communicator Receiver
DACT	Digital Alarm Communicator Transmitter
dB	Decibels
DBFL	Design Basis Flood
DDC	Direct Digital Control
DGP	Data Gathering Panel
DOE	Department of Energy
DOE/SSO	DOE Site Support Office
DPM	City of Albuquerque's Development Process Manual
EGL	Energy Grade Line
EIFS	Exterior Insulation Finish System
EPA	Environmental Protection Agency
ES&H	Environment, Safety, and Health
ESP	Engineering Standards Program
FACP	Fire Alarm Control Panel
FAIT	Facilities Asbestos Implementation Team
FCC	Facilities Control Center
FCS	Facilities Control System
FDPQARF	FMOC Design Package Quality Assurance Review Form
FEMP	Federal Energy Management Program
FID	Field Interface Device

Acronyms, Abbreviations, and Key Terms

FM	Factory Mutual
FMOC	Facilities Management and Operations Center
FSE	Facility System Engineer
GFCI	Ground Fault Circuit Interrupter
GPP	General Plant Project
HCC	Headquarters Communications Center
HEPA	High Efficiency Particulate
HGL	Hydraulic Grade Line
HOA	Hand-Off-Auto
HPS	High-Pressure Sodium
HVAC	Heating, Ventilating, and Air Conditioning
IA	Intrusion Alarm
IBC	International Building Code
IBMT	Infrastructure Building Management Team
IBR	Institute of Boiler and Radiation Manufacturers on Hydronics Institute
ICC	International Code Council
IDC	Initiating Device Circuit
IDR	Intermediate Distribution Room
IEEE	Institute of Electrical and Electronics Engineers
IESNA	Illuminating Engineering Society of North America
IFC	International Fire Code
IMC	International Mechanical Code
IPC	International Plumbing Code
IRI	Industrial Risk Insurers
KAFB	Kirtland Air Force Base
LCC	Life Cycle Cost
LED	Light Emitting Diode
LEED	Leadership in Energy and Environmental Design
LEV	Local Exhaust Ventilation
LOTO	Lockout/Tagout
MCC	Motor Control Center
MCU	Multiplexer Control Unit
MHID	Metal Halide
MPFL	Maximum Probable Fire Loss
NAC	Notification Appliance Circuit
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NETA	International Electrical Testing Association
NFPA	National Fire Protection Association
NICET	National Institute for Certification in Engineering Technologies
NIST	National Institute of Standards and Technology
NNSA	National Nuclear Security Agency
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Emissions System

Acronyms, Abbreviations, and Key Terms

NPW	Non-Potable Water
NRCA	National Roofing Contractors Association
ODP	Open, Drip-Proof
PM	Preventive Maintenance
PIV	Post Indicator Valve
PRV	Pressure Reducing Valve
psig	Pounds per Square Inch Gauge
PT	Potential Transformer
QA	Quality Assurance
RFI	request for information
RFQ	Request for Quotation
RPBFP	Reduced Pressure Backflow Prevention
Sandia/NM	Sandia National Laboratories/New Mexico
SAR	Safety Analysis Report
SAS	Secondary Alarm System
SCIF	Sensitive Compartmented Information Facility
SDR	Sandia Delegated Representative
SFM	Sandia Furnished Material
SLC	Signal Line Circuit
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
SRN	Sandia/NM Restricted Network
SSOV	Safety Shut-Off Valves
SWPPP	Storm Water Pollution Prevention Plan
TEFC	totally enclosed fan cooled
UDS	Uniform Drawing System
UFAS	Uniform Federal Accessibility Standards
UL	Underwriters Laboratories
USGBC	United States Green Building Council
VAV	Variable Air Volume
VFC	Variable Frequency Controller

Chapter 1 - Introduction to the Facilities Design Standards Manual

1.1 1Introduction

This manual is written for Facilities Engineers and Architect/Engineers (A/Es) who perform work for the Sandia National Laboratories/New Mexico site (Sandia/NM). Contents of this manual represent institutional knowledge derived from Design, Construction Management, Operations, and Maintenance by the Facilities Maintenance and Operations Center (FMOC). To be more efficient and effective in managing Sandia/NM's extensive construction and drawing files, design work, including Conceptual Design Report (CDRs) and Design Criteria, shall reference this manual first. Variances from these standards will require approval from the appropriate discipline engineer of the Engineering Standards Committee. The Standards Committee shall determine acceptability of variances with input from Systems Engineering, Construction Inspection and Acceptance, and Maintenance.

This manual contains general requirements that apply to non-nuclear facilities and non-explosive facilities. For design and construction requirements for modifications to nuclear or explosive facilities, see the project specific design requirements noted in the Design Criteria.

1.2 References

Unless otherwise noted, comply with the latest editions of the following documents:

1.2.1 Department of Energy (DOE) Orders and Standards

1. DOE Order 413.3, Program and Project Management for the Acquisition of Capital Assets.
2. DOE Order 420.1A, Section 4.4, Facility Safety, Natural Phenomena Hazards.
3. DOE Standard 1021-93, chg 1, Natural Phenomena Hazards Performance Categorization Guideline for Structures, Systems and Components.
4. DOE Order 414.1A, Quality Assurance.
5. DOE Guide 430.1-1, Cost Estimating Guide.
6. DOE Order 430.2A, Departmental Energy and Utilities Management
7. DOE Standard 1020-2002, Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities
8. DOE Standard 1021-93, Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components
9. DOE Manual 473.1-1, Physical Protection Program Manual

1.2.2 Codes of Federal Regulations (CFRs)

1. 10 CFR 436 subpart A (Methodology and Procedures for Life Cycle Cost Analysis).
2. 29 CFR 1910, Occupational Safety and Health Standards, Subpart G, 1910.95, Occupational Noise Exposure.
3. 29 CFR Part 1910, Occupational Safety and Health Standards
4. 29 CFR Part 1926, Occupational Safety and Health Regulations for Construction

1.2.3 Commercial Codes and Standards

1. National Fire Protection Association (NFPA) 70, National Electrical Code.
2. NFPA 13, Installation of Sprinkler Systems
3. NFPA 72, National Fire Alarm Code.
4. NFPA 75, Protection of Electronic Computer/Data Processing Equipment.
5. NFPA 90A, Installation of Air-Conditioning and Ventilating Systems.
6. NFPA 90B, Standard for the Installation of Warm Air Heating and Air Conditioning Systems.
7. NFPA 101, Life Safety Code.
8. NFPA 318, Protection of Clean Rooms.
9. NFPA 780, Lightning Protection System.
10. NFPA 2001, Clean Agent Fire Extinguishing Systems
11. Americans with Disabilities Act Guidelines (ADA).
12. Federal Highway Administration, Manual on Uniform Traffic Control Devices
13. Illuminating Engineering Society of North America (IESNA) Lighting Handbook, 9th Edition or later.
14. International Building Code, IBC 2003 (excluding the International Electrical Code).
15. International Mechanical Code (IMC) 2003.
16. International Fire Code (IFC) 2003.
17. International Plumbing Code (IPC) 2003.
18. Uniform Federal Accessibility Standard 795 (UFAS).
19. American Society of Heating, Refrigeration, and Air Conditioning (ASHRAE) Standard 60-1998.
20. ASHRAE Standard 62-1999.
21. ASHRAE Standard 90.1-1999 (including 2001 amendments).
22. ASHRAE Standard 90.2-1993.
23. ASHRAE Standard 100-1995.
24. ASHRAE Project 308-1985.
25. ASHRAE Duct Fitting Database.
26. Sheet Metal and Air Conditioning Contractors National Association (SMACNA) HVAC Duct Construction Standards – 1995.
27. American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE) C2, *National Electrical Safety Code,* Latest edition.
28. ICC/ANSI A117.1 – Standard on Accessible and Usable Buildings and Facilities.
29. IEEE 315, Graphic Symbols for Electrical and Electronic Diagrams.
30. IEEE "Color Book Series."
31. IEEE-519-1992, Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.
32. National Roofing Contractors Association (NRCA) Roofing and Waterproofing Manual.
33. NRCA Handbook of Accepted Roofing Knowledge.

1.2.4 Sandia/NM Standards and Specific References

1. Facilities Construction Standard Specifications
2. Facilities Standard Drawings
3. Facilities Computer-Aided Drafting and Design (CADD) Standards Manual
4. Sandia/NM Facility Campus Design/Development Guidelines

5. SNL Sign Standard for Exterior and Interior Signs Manual
6. Telecommunications Systems Design Guidelines
7. Site Modifications Review Process, Procedure No. AP-022
8. Vaults and Vault-Type Rooms (VTRs), CPR400.3.9

1.3 Document Organization

The manual is divided into the following chapters:

- Acronyms, Abbreviations, and Key Terms
- Chapter 1 – Introduction to the Facilities Design Standards Manual
- Chapter 2 – General Design Standards and Procedures
- Chapter 3 – Civil Design Standards
- Chapter 4 – Landscape Design Standards
- Chapter 5 – Structural Design Standards
- Chapter 6 – Architectural Design Standards
- Chapter 7 – Fire Protection Design Standards
- Chapter 8 – Mechanical Design Standards
- Chapter 9 – Electrical Design Standards
- Chapter 10 – Telecommunications Design Standards
- Chapter 11 – Security Design Standards
- Chapter 12 – Attachments

1.4 Document Updates and Printing Instructions

As industry standards and practices cited in this manual change, updates will be issued with revision dates indicated in the page footer, and tracked changes will be highlighted in the Microsoft Word electronic file. The intent is to update the manual when changes are warranted. Consult Sandia's external web page, http://www.sandia.gov/engstds, for the current version.

Update notices will be sent by e-mail to those company representatives on Sandia/NM's distribution list. Each A/E and Contractor is responsible for accessing the web page, downloading the appropriate files, and updating and managing the files at his/her office for use on Sandia/NM's projects. In addition, Construction Contractors are responsible for distributing the changes to their subcontractors (if any).

This is a large, multidisciplinary document (well over 200 pages). To print individual pages or chapters of this document, refer to the printing instructions in Attachment 1.

1.5 Executive Summary

Facilities' design, construction, operation, and maintenance shall be based on incorporation of industry standards, a graded approach, and the systematic analysis of life-cycle benefits received for the costs incurred. Design of the physical plant shall ensure that the facilities are "fit for use," and provide facility conditions that effectively, efficiently, and safely support Sandia/NM's current and future mission need. In addition, sustainable design principles shall be applied, using an integrated whole-building design approach, from site planning to facility design,

construction, and operation to ensure resource efficiency of the building and improve the health and productivity of the occupants. The safety and health of employees and the public, and any possible impact to the environment, shall take precedence over project issues such as performance, cost, or schedule.

These design standards are generally applicable to all disciplines on all Sandia/NM projects. Architectural and engineering design shall be both functional and cost effective. Facility design shall be tailored to fit its intended function, with emphasis on low-maintenance, energy-efficient, and energy-conscious design. Design facilities that are easily maintained, with readily accessible equipment areas, low maintenance, and quality systems. To promote an orderly and efficient appearance, architectural features of new facilities shall complement and enhance existing architecture at the site. The A/E shall advise the Project Manager when this approach is prohibitively expensive.

The A/E is encouraged to use professional judgment and ingenuity to produce a coordinated interdisciplinary design that is cost effective, easily contractible/buildable, high-performing, and aesthetically pleasing. Close coordination and development of civil, landscape, structural, architectural, fire protection, mechanical, electrical, telecommunications, and security features is expected to ensure compatibility with planned functional equipment and to facilitate constructability.

The A/E, along with support consultants, shall perform functional analyses and programming in developing design solutions. These solutions shall reflect coordination of the competing functional, budgetary, and physical requirements for the project. During design phases, meetings to discuss and resolve design issues will be required between the A/E and the Sandia/NM Project Team. These meetings will be a normal part of the design process. For specific design review requirements, see the project-specific Design Criteria.

In addition to the design requirements presented in this manual, instructive information is provided to describe the sustainable building practice goals for design, construction, operation, and maintenance of Sandia/NM facilities. A/Es performing work are encouraged to notify Sandia/NM of design best practices that are not included in this manual so that such practices can be incorporated into future updates.

The A/E shall convey all documents describing work to the Sandia/NM Project Manager in both hard copy and in an electronic format compatible with the Sandia/NM prescribed CADD and other software packages, and in accordance with a Sandia/NM approved standard format. All hard copy versions of submitted documents (excluding drawings and renderings) shall be printed double-sided when practical.

- End of Chapter -

Chapter 2 - General Design Standards and Procedures

2.1 Introduction

The A/E is responsible and accountable for the final design of a project, per requirements noted in this document, the project-specific Design Criteria (when included), and additional contract documents. It is the A/E's responsibility to provide a facility design that meets the required functions in the most cost-effective manner to meet Sandia/NM's current mission needs and provide flexibility, as requested, to meet Sandia/NM's anticipated future mission needs.

2.2 Design Process

The A/E is responsible for determining all requirements necessary to create a comprehensive, functional, buildable design. The A/E shall use resources such as the Conceptual Design Report, Design Criteria, Building Systems Summaries (available for major facilities from the Systems Engineer), this Design Manual and additional information gathered through the Title I "Programming" exercise to determine solutions to design questions. Use of the Space Data form (available on the web site) during interviews of the project's stakeholders may prove fruitful.

During the initial phase of projects, conceptual design reports (CDRs) and design criteria are developed from an analysis of project requirements to establish functional and performance specifications and architectural design attributes. The development of CDRs and design criteria must be in alignment with the standards and methods of this manual. To ensure this alignment, initial design phase activities must also include the participation of the Sandia Project Team as well as facility owner, occupant, and maintenance representation.

The internal Sandia/NM Project Team generally consists of a Sandia/NM Project Manager and primary discipline leads (Architectural, Civil, Structural, Mechanical, Electrical, Controls, Fire Protection, Security, Telecommunications, and Safety) assigned to each project. A working relationship should be developed early in the project between the A/E team and the Sandia/NM team to expedite the transfer of additional required information. At times the A/E should be aware, however, that they might be required to go directly to additional Sandia/NM stakeholders to obtain additional design direction if the internal team counterpart is not available. All correspondence of this type must be documented and copied to the applicable Sandia/NM team members. The Sandia/NM Project Manager should provide an expanded list of all project "stakeholders" to the A/E early in design. Any changes involving scope, schedule, or impact to the project baseline shall be identified immediately to the Sandia/NM Project Manager.

2.3 Design Quality

Architectural and engineering design shall be both functional and cost effective. Carefully tailor the facility's design to fit its intended function, using sustainable design principles, including but not limited to low maintenance, energy and water efficiency, material and resource conservation, and indoor environmental quality. Design facilities that are easily maintained, with readily accessible equipment areas, low maintenance interior and exterior surfaces, and quality roofing

systems. To promote an orderly and efficient appearance, architectural features of new facilities shall complement and enhance existing architecture at the site.

As in any design process, the A/E shall begin with informed assumptions and proceed to identify solutions. As problems gain more definition and as alternative solutions become more refined, the A/E is encouraged to use professional judgment and ingenuity to produce a coordinated interdisciplinary design that is cost effective, easily contractible, high-performing, and aesthetically pleasing. Closely coordinate development of civil, landscape, structural, architectural, mechanical, electrical, telecommunications, and security features to ensure compatibility with planned functional equipment and to facilitate constructability.

The A/E, along with support consultants, shall perform functional analyses and programming in developing design solutions. These solutions shall reflect coordination of the competing functional, budgetary, and physical requirements for the project. Prior to and throughout the design process, meetings to establish, discuss, and resolve design issues will be required. These meetings will be a normal part of the design process and are critical to achieving a fully integrated, whole-building design. For specific design review requirements, see the project-specific Design Criteria.

Value engineering, which always include the customers and follows a result-driven job plan of a Selection Phase, an Information Phase, a Creativity Phase, an Analysis Phase, a Development Phase, a Presentation Phase, an Implementation Phase, and a Verification Phase, has been shown by many others to provide significant savings and a project design most appropriate to its purpose. These savings are most significant when value engineering begins during the programming stage of the design and is continued throughout the design. It is Sandia/NM's experience that value engineering not only provides the most notable savings in project costs when initiated at the outset of the design and scooping, but that is the time when it is the least expensive to perform, often resulting in design guidance that can eliminate further value engineering sessions after the Title I (second) value engineering session.

Throughout the design process, the A/E shall chair discipline coordination sessions to deconflict the use of building space by the various construction disciplines. In the concept definition phases and up to 30% completion, this should result in mechanical and electrical rooms, utility chases both intrafloor and interfloor, and outdoor equipment such as substations and cooling towers being blocked-out on the early drawings. As equipment items are chosen up to 60% completion, these should be refined to include feeder conduit and liquid piping runs, major ductwork runs, equipment locations on the utility room floor plans and outside, and general assignment of interstitial spaces above ceilings and in chases. At 90% completion and with delivery of the final contractual design package, all such discipline conflicts shall have been resolved, to include but not be limited to consideration of the following:

- NEC clearances and exit paths for electrical panelboards, switchgear, and drives
- Access to air handlers and other HVAC equipment, including space to service filters, fan belts, motors, and bearings, remove heat exchanger components, etc

- Clear space to open all access doors and panels fully, with the understanding that doors of one equipment item may swing into the clearance space of another when the second item does not require simultaneous access
- Design of service lights, catwalks, and convenience receptacles in larger interstitial spaces where the room lighting and receptacles may be inadequate
- Three-dimensional space assignment of the disciplines in interstitial spaces and chases
- Structure-mounted pick points and dolly space for removal and replacement of major items such as a large motor
- Location of lighting fixtures such that they are not blocked by other equipment and that they cast light into occupiable spaces and not (for instance) on top of a fume hood. This includes arrangement of fixtures in a lay-in ceiling to accommodate modular furniture and not just in a symmetrical pattern for an empty room.
- Location of VAV boxes such that they can be serviced easily
- Location of electrical junction boxes for lighting, communications, alarms and access control, and other systems which could reasonably be expected to require periodic access during the life of the building, such that access to each item does not require dismantlement or outages of items not related to that discipline
- Minimize the location of major items within a vault type area such that they are not readily accessible for servicing, even when dedicated to that vault type space
- Location of outside equipment such that adjacent space use is compatible; for instance, not locating an air intake near a vehicle area, and not locating fire sprinkler and roof drains near pedestrian paths
- Partitioning of building utility space separate from (but may be adjacent with) programmatic utility runs
- Full design of conduit and piping runs of 2” and larger, and restricted use of home-run designators to smaller terminal runs and branch circuits
- Access means or choice of equipment items that afford ready servicing in lobbies, open stairwells, and other areas where ceiling height is multi-story

Portions of a facility design which are subcontracted, such as site preparation, asbestos remediation, and fire protection sprinkler design, shall be contracted for and delivered such that any effects of the contracted portion upon the A/E’s deliverable package may be considered by the engineer or architect with responsible charge and included so that the subcontracted effort will be an integrated part of the whole.

In accordance with the laws of the state of New Mexico, the deliverable design package shall be sealed by the engineers and architects in responsible charge of the design. Alterations to the design package, including the final red-lines, which materially change the original design and which result in the production of new or changed documents, shall be re-sealed.

2.4 General Requirements for Construction Drawing Files

2.4.1 Facilities CADD Standards Manual

Drawing files shall be created or modified to comply with the requirements listed in the Facilities CADD Standards Manual. This manual contains specific information and files related to CADD requirements, standards, and processes. Compliance with the manual is required for all individuals and companies when creating or modifying Sandia/NM Facilities drawing files. Exceptions to compliance requirements may be made prior to as-built issues as necessary to benefit the project if approved by the Sandia/NM Project Manager. No exception will be allowed for final as-built files. All plans, elevations, sections, details, and diagrams shall be prepared to sufficient size and detail to clearly and completely define the project for bidding and construction purposes.

2.4.2 Locating Drawing Files

Because facilities at Sandia/NM are continually being modified or extended, Facilities Engineering uses an active record drawing file system to represent those changes. Identification of the most up-to-date record drawing files that are affected by a particular project is part of the project design requirements. Half-scale hard copies and current, on-line, read-only access to numerous drawing files are available in the Facilities Engineering Library in Building 887, Room 1290. Note that the drawings may be outdated and information used to interface or develop the design shall be field verified.

2.4.3 Requesting Drawing Files from the Drawing File System

Facilities Engineering operates a closed drawing file system. Only authorized personnel with a valid user name and password may check out record drawing files. Off-site contractors are assigned an on-site CADD Technician as a point-of-contact for all files being checked in and out of the Facilities Document Management System. Refer to the Facilities CADD Standards Manual for specific information related to CADD standards and processes.

2.4.4 Use of Record Drawing Files

Modifications to existing facilities shall be made by revising the record drawing files, unless otherwise directed. New drawings shall be prepared if the existing record drawings are too crowded or obsolete. All plans, elevations, sections, details, and diagrams shall be completed to sufficient size and detail to clearly and completely define the project for bidding and construction purposes. Refer to the Facilities CADD Standards Manual for detailed instructions.

2.4.5 Drawing Numbering System

Distinguishable types of project drawing plot files that are commonly (or are specified to be) created on separate drawing files shall be numbered in a modified “Uniform Drawing System” numbering scheme as described in the Sandia/NM Facilities CADD Standards Manual.

2.4.6 Standard Drawings

Standard drawings are used to facilitate the design process by providing typical details and templates for incorporation into design packages. Although all of the drawings are called Standard Drawings, there are actually three categories of standard drawings:

1. **Standard Drawings-** These drawings are to be used as-is for construction. No modifications to these drawings are required beyond project-specific title block additions.
2. **Template Standard Drawings-** These drawings are to be used as a starting point to create a new building or utility drawing that will be assigned its own unique number and filed as such.
3. **Design Standard Drawings-** These drawings are to be used for design calculations and conceptual design layout. These drawings shall not be included in a construction set except for design-build projects.

Hard copies of standard drawings are located in Building 887, room 1290 in 11"x17" blue binders titled "Active Standard Drawings". These drawings are not to be removed from room 1290, though copies of the drawings may be made. All standard drawings are CADD vector files and are also available in PDF format. All A/Es on Sandia/NM's distribution list should have electronic copies of the standard drawings. If electronic copies are required but not available in the A/E system, the A/E should request them from the Sandia/NM Project Manager.

2.4.7 Drawing Set Organization

The construction drawing set shall be organized as shown in Table 2-1.

Table 2-1. Drawing Set Organization

Discipline	Discipline Designator
G	General
C	Civil
W	Civil Work
L	Landscape
S	Structural
A	Architectural
F	Fire Protection
P	Plumbing
M	Mechanical (Includes MI - HVAC Controls)
E	Electrical
T	Telecommunications
T	Security
	Other Disciplines (Non HVAC Controls, Asbestos, etc.)

2.5 Construction Specifications

2.5.1 Overview

The Facilities Construction Specifications include both Construction Standard Specifications and Master Construction Specifications. The Construction Standard Specifications contain broad specifications that are typically used in their entirety without modification. The Construction Master Specifications, on the other hand, must be edited specific to a project to reflect the options and applications used. All of these are available on the web site, http://www.sandia.gov/engstds.

If it is determined that a Construction Standard Specification needs content modifications to fit the project, consult with the Sandia/NM Project Team to discuss the extent of the changes. The Sandia/NM Team members may solicit comments or input on the proposed changes from systems engineering, construction, inspection, and maintenance. When a Specification is modified to fit the project, it becomes a Construction Special Specification. In general, the specifications are written in accordance with the Construction Specifications Institute (CSI) "Manual of Practice" and organized in CSI standard Divisions 1 through 16.

In the absence of a Construction Standard Specification, or if a Construction Standard Specification requires minor modification, project-specific special construction specifications may be produced by the A/E. All specifications shall be written in accordance with the Construction Specifications Institute (CSI) "Manual of Practice." The Standard Construction Specification template (also available on the web site) shall be used in preparing all specifications, and the electronic files (in MS-Word) shall be submitted as part of the project deliverables.

Any Sandia Standard or Master Construction Specification which is edited for a particular project, or any new Specification which is written for a particular project and does not have an existing Sandia counterpart, is considered to be a "Special Construction Specification" and valid only for the project in question. If it becomes apparent that a Special Specification should apply across the SNL campus, the Engineering and Architectural Standards Program Chair shall be notified and supplied with the document. Further editing to make the proposed document applicable for the entire campus, along with the justification and reasoning behind the proposed Specification's provisions, shall be provided to the E&ASP Chair, who will facilitate the discipline review and quality assurance process. A proposed new Specification will be remain a Construction Special Specification until approved in its final form by the E&ASP Committee as a new Construction Standard Specification.

2.5.2 Process for Editing an Existing Construction Specification, Creating a new Special Specification, and Documenting Variances from the Specifications:

This process has been made into a separate document and placed on the E&ASP website at: http://www.sandia.gov/engstds/ConstSpecs/Editing_a_standard_specification.pdf. A sample variance report is at Attachment 2 to this Manual.

2.6 Miscellaneous Design Issues

2.6.1 Sandia Furnished Material

Identify all Sandia Furnished Material (SFM) in the specifications and the construction contract. Verify that the existing equipment is functional for the intended use in the design.

2.6.2 Installation of Customer Equipment

When installing equipment owned by the end-use customer, it is the A/E's responsibility to document all installation issues associated with the equipment – including: size, weight, electrical, data communications, chilled water, exhaust, drains, serviceability, safety, etc.

2.6.3 Disposal of Customer Equipment

Construction contractors cannot take equipment owned by customers and not considered Facilities equipment, such as fume hoods, uninterruptible power supply units, etc., to Property Reapplication. They may disconnect the associated utilities, but the customer must make disposal arrangements directly with Property Reapplication.

2.6.4 Descriptive Submittals

Projects that require submittals shall be in accordance with the Facilities Construction Standard Specification Section 01330, Submittal Procedures. Prepare a summary sheet (Descriptive Submittal Form, available on the web site) of submittal requirements for each of the following disciplines:

- Civil
- Structural
- Architectural
- Fire Protection
- Mechanical
- Electrical
- Telecommunications
- Security
- Facilities Control System.

Consolidate and include these sheets as part of the construction package. The construction contractor typically submits information only for those items listed; therefore, list all necessary requirements to ensure full project compliance.

2.6.5 Master Equipment List (MEL) Update

When equipment items are removed or added to a building as part of a project, provide information to assist Sandia's Maintenance Planning Services department to update the MEL as appropriate. Compare your equipment selections and/or removals during design to the MEL Update Notification form. This is especially important and applicable for equipment replacements, and remodels and renovations involving equipment replacements, as well as new construction projects. Advise the SNL Facilities Project Manager (PM) or Design Team Discipline Lead, as applicable, of the scope of the project during design and provide the list of as-designed equipment to be provided/removed. The list should become a part of the design package and updated during construction, as necessary, by approved submittals or change orders.

2.6.6 Temporary Services

Prepare complete designs for all temporary service connections and installations required for the contractor's use of government-owned utilities. These designs are subject to requirements noted herein.

2.6.7 Site Access Requirements

Most areas at Sandia/NM are subject to security and access regulations. To obtain access to the Project areas, the A/E is to submit a letter to the Sandia Delegated Representative (SDR) identifying personnel needing access, company name or affiliation, and the anticipated dates and times of visits. Those who have an active DOE L or Q clearance will be furnished temporary badges that permit access. All others will be provided an escort while in the secure area. All personnel are required to have a badge regardless of whether they are in a secure area or not. Contact the SDR at the beginning of the project for additional details.

2.7 Design Narrative and Calculations

Design drawings for all disciplines shall be accompanied by sufficient narrative and supporting calculations to clearly convey assumptions, constraints, and how code requirements have been met. Additionally, narrative on design of chemical rooms, service/storage areas/yards, and/or other elements including hazardous materials and life safety implications shall include relevant reference to code-driven tables, and calculations (and calculation sheets). Such narrative and calculations shall be provided with each submittal.

Present narrative and design calculations on 8-1/2- by 11-inch sheets with minimum ½-inch margins on all sides. Logically arrange, index, and bind the sheets in book form. Type or hand-letter all material. Neatly arrange the sheets and include the sources of all contents. Present the formulas used and clearly state all assumptions made. Present the following information on each sheet:

- Sandia/NM Project number
- Sheet number
- Subject
- Date.

Include items such as the following as supporting information:

- Flow diagrams
- Free-body diagrams
- One-line schematic diagrams
- Utility system calculations
- Sandia/NM-provided information and direction.

When using computer-aided design systems to perform design calculations, also include:

- The computer program name and version used.
- Information on the building model or paradigm used by the software, so that an engineer unfamiliar with the program can understand the functions, limitations, and method of analysis used. The documentation shall be sufficiently complete to allow an engineer to verify the method of data input and interpret the output calculation by hand. This requirement can be waived if the software is also in use at Sandia/NM.
- Identification of the free-body diagrams, one-line power diagrams, marked plans, flow diagrams, sketches, etc., which are part of the design package so that another engineer can easily check for accuracy. This can be part of the calculations pages mentioned above.
- A copy of the computer output. (Retain a complete copy of input data, worksheets, discs, and other quality assurance records with the project file for possible audit purposes.)
- Spot-reviews or verifications of the computer output for accuracy and reasonableness.

2.8 Energy Conservation and Sustainable Design Requirements

2.8.1 Goal

Sandia/NM's Facilities Management and Operations Center (FMOC) goal is to provide buildings and infrastructure that promote a healthful, resource-efficient, and productive working environment. To achieve this goal, all new buildings and renovation projects shall be designed, constructed, and commissioned for operation using an integrated whole-building design approach and the latest sustainable building technologies. Every reasonable effort will be made to employ life cycle cost-effective energy and water conservation concepts during design and construction based on the total established value engineering concepts that also ensure an appropriate balance on project cost, security, maintainability and facilities life-cycle costs.

Sandia is included in the list of Federal agencies which are required by the Energy Policy Act of 2005 (Public Law 109-58) to incorporate the performance criteria used for ENERGY STAR® qualified and FEMP-designated products into procurement contracts for energy consuming products and systems. These include Construction Specifications; construction, renovation and service contracts; and the designs to be developed using this Manual.

2.8.2 Objectives for Laboratories and Offices of the 21st Century

One objective of this Design Manual is to pursue design and development of high-performance, energy-efficient buildings and infrastructure at Sandia/NM that will minimize environmental impacts, protect occupant safety, optimize whole building efficiency, and establish goals, track performance, and share results for continuous improvement. To demonstrate a commitment to

these goals and objectives, the following strategies, as confirmed by the responsible Sandia/NM Project Manager, shall be pursued for all project work at Sandia/NM:

- Adopt energy and environmental performance goals to minimize energy consumption and reduce environmental impacts.
- Assess opportunities from a whole-building approach to maximize energy and water conservation through comprehensive, integrated evaluations of all components, systems, and, as appropriate, processes.
- Use life cycle cost decision-making balanced with first cost constraints.
- Commission equipment and controls in all new construction and renovation projects as an integrated effort during construction, to verify building system performance and functionality for the Users and for Facilities operations and maintenance.
- Employ a broad range of advanced energy and water efficiency strategies, including but not limited to central plant optimization, airside supply and exhaust distribution optimization, energy recovery methods, lighting design optimization, and water use reduction measures.
- Measure energy and water consumption using the campus' Facility Management System (FMS) monitoring abilities, or by other means if FMS is not available.
- Specify environmentally preferable construction materials and construction waste reduction methods.
- Seek recognized certifications that demonstrate this philosophy, such as LEED, Energy Star, and Green Building awards and certificates.

2.8.3 Life Cycle Analysis

Federal Energy Management Programs (FEMP) have established 10 CFR 436 to promote life cycle cost (LCC) effective investments in building energy systems, building water systems and energy and water conservation measures for Federal buildings. This life cycle cost methodology is a systematic analysis of relevant costs, excluding sunk costs, over a study period, relating initial costs to future costs by the technique of discounting future costs to present values. Performance of LCC analysis early in the design process is critical because studies have shown that after 1 percent of the project costs have been incurred, up to 70 percent of building life cycle costs have been committed. As a result, Sandia/NM requires the use of value engineering and life-cycle cost analyses in these early phases of Line Item projects to support sustainable development. The earlier in the project development process that value engineering and life-cycle costing are employed, the greater the potential benefits for sustainable development and cost savings.

While value engineering is intended to determine the project component alternatives that satisfy the same basic function or set of functions at the optimum project cost, life-cycle costing is intended to actually make economic comparisons between systems similar in function and enable selection of the lowest life-cycle cost system. Combining value engineering and life-cycle costing has the potential to identify the best value alternative by comparing the first cost and life-cycle costs of each alternative. In this manner value engineering and life-cycle costing are both used during the early project phases to develop an "equal playing field" for determining tradeoffs and making decisions to balance environmental performance with total cost, reliability, safety,

and functionality. This equal comparison enables sustainable development technologies and integration to be fully evaluated for overall performance.

As stated below, an integrated project team approach is critical to achieving an integrated whole building design. As such, value engineering and life-cycle cost professionals should be included in the design team at the earliest possible phases of the project. Sustainable design features may be eliminated or substantially compromised if value engineering is not applied until the final stages of design, which is typically when value engineers become part of the project team in response to cost overruns. The framework for integrating value engineering and life-cycle costing with sustainable design is as follows:

- Perform a requirements assessment to establish the parameters for sustainable development
- Perform conceptual planning using macro-level value engineering and life-cycle costing (which includes energy modeling)
- Conduct programming and budgeting activities
- Perform design and construction using complete value engineering and life-cycle costing evaluations
- Perform commissioning tasks.

2.8.4 Sustainable Design

2.8.4.1 General

Sustainable (or green building) design is intended to minimize site disturbance, optimize energy and water use, provide good indoor environmental quality, select environmentally preferable building products, handle construction and demolition waste in a resource-conserving manner, and improve operations and maintenance.

Several statutory and regulatory requirements have been established to institutionalize sustainable design at DOE facilities, including Sandia/NM. Brief descriptions of these requirements are presented below:

- DOE Order 413.3 (Project Management) establishes that sustainable design principles shall be followed in the siting, design, and construction of Federal facilities.
- Executive Order 13123, Section 403(d), instructs Federal agencies to develop sustainable design principles and use them in planning and building new facilities.

Two references are commonly recognized as the standard for Sustainable Design and Development of Buildings and Infrastructure. The U.S. Green Building Council (USGBC) has developed the Leadership in Energy and Environmental Design (LEED) Green Building Rating System to evaluate life cycle environmental performance from a whole-building perspective. Information on this rating system can be found at http://www.leedbuilding.org. In addition, an interagency Federal task force has developed a set of sustainable design and development principles, comparable to the LEED rating system, known as the Whole Building Design Guide (http://wbdg.org). Both of these programs provide excellent information and should be referenced while conducting facility planning and design work for Sandia/NM.

Sandia/NM issued a communiqué in February 2001 to encourage the use of sustainable design principles by A/E firms for work conducted at Sandia/NM. It is expected that A/E firms that market sustainable, energy efficient design as part of their services will assist Sandia/NM FMOC in institutionalizing sustainable design efforts. As always, Sandia/NM expects to produce functional, efficient, healthful, and compliant infrastructure and facilities.

2.8.4.2 LEED Certification

Sandia/NM intends for all new buildings and major renovation projects to be capable of certification as a "green" building through the LEED rating system. Therefore, all new building and major renovation designs (unless specifically not required by the project-specific Design Criteria or the Sandia/NM Project Manager), will be scored using the LEED rating system, in anticipation of submission for certification as a Green building. Actual LEED certification requires applicant buildings to satisfy a number of prerequisites and attain a certain number of credits. Once the LEED program prerequisites have been satisfied, applicant buildings are rated based on the number of credits achieved within the rating system. There are four levels of LEED certification: Certified, Silver, Gold, and Platinum (highest).

The certification process first requires registration of the building project with the USGBC to show intent to obtain LEED certification. The USGBC recommends registering early in the project, preferably during the schematic design phase. Following completion of construction activities, an application is submitted to the USGBC LEED Certification Manager. This application includes a narrative of the project, a LEED Scorecard, complete documentation per credit (tabbed) with cover sheets from the Application Template, and a certification fee. Sandia/NM's requirement for a Sustainable Design Report during the design process of major building projects significantly aid in this application process. The application then goes through an administrative review, a technical review, followed by notification of LEED Certification. The USGBC presents the project with a certificate and a metal LEED plaque indicating the certification level. The standard review timeline can take anywhere from eight weeks to several months. As a member of the USGBC in the Government-Owned, Contractor-Operated category, Sandia/NM building projects are entitled to receive membership benefits and discounts on fee schedules relating to the registration, technical support, and certification process.

2.8.4.3 Whole Building Design Approach

Sandia recommends an integrated whole building design approach to all new construction and major renovation projects. This approach to design is based on the consideration of interrelationships among building siting, design elements, energy and resource constraints, building systems, and building function, before pre-design activities are initiated. To identify the effects these factors have on one another requires a multidisciplinary design and construction team consisting of site planners, landscape architects, architects, engineers, contractors, interior designers, lighting designers, building owners, occupants, maintenance personnel, and any other relevant stakeholders. Such a multidisciplinary team must be assembled prior to initiation of design activities to ensure the coordination of individual design efforts and sharing of specialized expertise to achieve an integrated whole building design process.

2.8.5 Building Systems Commissioning

Sandia/NM requires that all new construction and major renovation projects include building systems commissioning as a quality control measure. At a minimum, commissioning procedures will verify and ensure that fundamental building elements and systems are designed, installed and calibrated to operate as intended. The following fundamental best practice commissioning procedures will be followed:

- Designate a commissioning authority, preferably during preliminary design
- Document the design intent and basis for design for each element and system included in the scope of commissioning
- Create a commissioning plan during the design phase
- Integrate commissioning requirements in the contract documents
- Verify installation, functional performance, training, and documentation
- Prepare a commissioning report upon completion of functional testing, with action plan to ensure completion of building systems commissioning effort

Sandia will designate the commissioning team or commissioning authority, as appropriate for the project. Ensure that the appropriate budget for commissioning has been established by the Project Manager, approximately 1.0-1.5% of construction cost.

2.8.6 Energy Service Meters

Each distinct building energy service shall have a measurement system provided to accumulate a record or indicator reading of the overall amounts of the electricity and natural gas being delivered. Exception: A building of 5,000 gross square feet or less in a complex of buildings may have its measurement system included with another building in the same complex.

Equip all required meters with provisions to allow for remote reading throughout the Sandia/NM Energy Metering System.

2.8.7 Energy Monitoring and Control Systems

Any new permanent building greater than 5,000 square feet shall have a Facilities Control System provided for interconnection with the Sandia/NM Facilities Control System, unless specifically exempted by the project-specific Design Criteria and/or the Sandia/NM Project Manager.

2.9 Conceptual Design (Project Definition) Requirements

If included in the A/E's contract, the Conceptual Design scope and deliverables shall include:

- Updated Functional & Operational Requirements documents
- Space and equipment data sheets
- Updated record drawings for Request for Quotation (RFQ) purposes
- Site plans
- Floor plans
- Building elevations

- Building sections.

2.10 Title I (Schematic Design) Requirements

Present the following items for Title I Quality Assurance Review (unless stated otherwise by Design Criteria):

- Design analysis (design narrative and calculations)
- Drawing prints and files
- Preliminary cost estimates
- All additional requirements as defined in the project-specific Design Criteria.

These Title I review requirements are described in the following sections.

2.10.1 Design Analysis

Present conceptual design analyses for the entire facility or portions thereof, including appropriate environmental or utility systems when required. The conceptual design analyses for alternate approaches to the job shall include:

- Statement of purpose and function
- Statement of factors considered and provided for
- Economic justification
- References of previous studies of record.

In general, these analyses present the complete documentation of the facts that are considered when forming conclusions for alternate approaches.

After the analyses have been considered and a choice agreed on in conference with the SDR, complete the chosen conceptual analysis and submit it at Title I. At a minimum, it shall contain the pertinent facts involved in the concept, the conclusions reached along with the reasons for these conclusions, and the alternates considered.

2.10.2 Drawings

The Design Criteria should determine the specific requirements for determining percentage complete for each discipline prior to starting design. If not indicated, the Title I final submittal shall be approximately 30 percent complete for the entire project.

A. Civil
   1. Complete drawing list (for example):
      a) Grading, drainage, and paving concept plan
      b) Utility location and connection point plan
         (1) Water
            (a) Domestic
            (b) Fire Protection
         (2) Sanitary Sewer
         (3) Power

(4) Communications
(5) Gas
(a) Propane
(b) Natural gas if available

2. Reasonably complete site plan and removal plans
3. Utility plans
4. Grading plans
5. Preliminary utility profiles

B. Landscaping
1. Site plans
2. Details

C. Structural
1. Complete drawing list
2. Load requirements (design parameters)
3. Foundation and Framing Plans (70 percent complete)
4. Non-typical sections and detail cuts
5. Typical details
6. Elevations:
a) Braced frames
b) Trusses

D. Architectural
1. Complete drawing list (for example):
a) Code analysis
b) Dimensioned floor plan
c) Dimensioned building elevations
d) Dimensioned building sections
e) Typical exterior wall section
f) Room finish schedule
2. Typical sections
3. Reasonably complete floor plans (defined as 70 to 80 percent complete)
4. Principal elevations

E. Fire Protection
1. Sprinkler layout plans
2. Fire alarm plans

F. Mechanical
1. Complete drawing list (for example):
a) Heating, ventilating, and air conditioning (HVAC) system(s)
(1) Evaluation and selection of systems
(2) HVAC concept floor plan
b) Plumbing and piping
(1) Plumbing conceptual floor plan
(2) Compressed air conceptual floor plan
2. Preliminary equipment list
3. Reasonably complete floor plans showing locations of major items of equipment, pipe and duct routing, air registers, and/or grills

4. Preliminary flow diagrams with major control items, shutoff valves, and tanks. When Facilities Control System monitoring and direct digital control is selected, show all necessary control sensors and the complete sequence of operation on the flow diagram.

G. Electrical
   1. Complete drawing list (for example):
      a) One-line power diagram
      b) Lighting layout plan
      c) Power plans
      d) Lightning protection grounding plans
   2. Preliminary lighting fixture layout
   3. Preliminary receptacle layout
   4. One-line power diagram, 90 percent complete
   5. Other systems–location, size, and type of major components.

H. Telecommunications
   1. Port location plan

I. Security
   1. Sensor locations
   2. Diagrams and details

2.10.3 Preliminary Cost Estimates

Preliminary Construction Cost Estimates will be submitted along with the Title I package. Estimates shall be prepared per requirements noted in DOE Order 430.1-1, "Cost Estimating." Additional direction may be provided in the Design Criteria. Appropriate labor rates for use in the estimate shall be confirmed with the Project Team, and procurement analysis (make or buy, design build) shall be adequately addressed by the Project Team for use in the estimate.

2.11 Title II (Design Development) Requirements

2.11.1 Deliverables

Present the following items for Title II Review (100 percent complete):

2.11.1.1 Drawings

Complete working drawing prints and files, prepared as outlined in this manual, including all plans, elevations, sections, details, diagrams, and notes required to completely delineate the job. For example, the following will be required:

A. Civil
   1. Complete drawing list
   2. Complete site plan and removal plans
   3. Utility plans
   4. Grading plans
   5. Utility profiles
   6. Communication duct bank section and typical details
   7. Utility demand calculations and sizes

B. Landscaping

1. Site plans
2. Details

C. Structural
   1. Complete drawing list
   2. Updated Load requirements (Design Parameters)
   3. Foundation and Framing Plans
   4. Sections and detail cuts
   5. Elevations:
      a) Braced frames
      b) Trusses

D. Architectural
   1. Enlarged partial floor plans
      a) Restrooms
      b) Darkrooms
      c) Control room(s)/area(s)
   2. Reflected ceiling plans
   3. Door and window schedule
   4. Interior elevations at key areas
   5. Expansion joints if applicable

E. Fire Protection
   1. Automatic sprinkler plans and details
   2. Fire alarm
      a) Floor plan and details
      b) Riser diagram

F. Mechanical
   1. HVAC
      a) Size major HVAC components
      b) Provide HVAC air flow criteria/requirements
   2. Plumbing and piping
      a) Size plumbing and compressed air systems
      b) Riser diagrams for plumbing and compressed air
      c) Fixture schedule
      d) Enlarged partial floor plans for key areas

G. Electrical
   1. Lightning and grounding protection plan
   2. Fixture schedule
   3. Lighting plans
   4. Lighting control diagram (as applicable)
   5. Power plans
   6. One-line diagrams
   7. Detail drawings
   8. Panel schedules
   9. Updated calculations and coordination study

H. Telecommunications
   1. All drawings listed in the Telecommunications Systems Design Manual

I. Security

1. Access control plans and details
2. Intrusion alarm plans and details

2.11.1.2 Specifications
Complete construction specifications prepared in the procedures outlined in this manual.

2.11.1.3 Design Analysis
Final calculations shall be complete with all background source material. This material shall be neatly indexed and bound.

2.11.1.4 Filled out Sandia/NM Constructability Checklist
This checklist shall be provided to the A/E by the Sandia/NM Project Manager at the beginning of the project.

2.11.1.5 Cost Estimate
The Final Construction Cost Estimate shall be submitted along with the Title II package. The estimate shall be prepared per the requirements noted in DOE Order 430.1-1, "Cost Estimating." Additional direction may be provided in the Design Criteria. Organize and segregate the estimate so that all exterior work is identified in a separate category. SFE shall be included and identified as a separate category.

2.11.1.6 Energy Conservation Report (as required by Design Criteria)
Submit a Final Energy Conservation Report containing the results of energy consumption calculations for the base case building and the results of the energy analysis and life cycle cost analysis for any energy conservation alternatives. Provide electronic files (Microsoft Word and Excel) and data files of computer calculations complete to the extent that Sandia/NM could achieve the same results.

2.11.2 Bid Support
Prior to award of construction contract, the A/E shall be required to support the Sandia/NM Project Team in the following areas:

- Attendance at the pre-bid conference
- Responses to bidders' requests for information (RFIs)
- Correction of design errors or omissions in the form of pre-bid addendums
- Possible review of certain elements of the construction proposals prior to Award of Contract.

2.12 Title III Requirements

Perform the following Services as part of Title III services (as noted in the contract):

- Responses to construction contractor RFIs
- Review and approval of descriptive submittals
- Resolution of constructability change orders
- On-site representation at the construction site

- Attendance at construction progress meetings
- Provide information for Safety Analysis Report
- Site observations.

As-build the following documents as part of Title III services (as noted in the contract).

2.12.1 Drawings and Specifications

Provide accurate and complete notes on prints regarding all construction changes and the exact locations of underground utilities encountered or installed. The contractor shall update records and drawings daily so complete compliance with the plans and specifications can easily be determined at any time. A check-off procedure, such as an initial or tick mark on items approved, is required. Revise all tracings and specifications to agree with the construction as actually accomplished. If a drawing in the as-built drawing set has not changed, stamp it "As-Built, No Change."

2.12.2 Calculations

Update the calculations books with any changes required during the course of construction.

2.12.3 Correspondence

Deliver all communications and memos that contain pertinent final information to the SDR for record purposes. Organize the sheets in a chronological order of the life of the project.

2.12.4 Descriptive Submittals

Deliver to the SDR all descriptive submittals such as shop drawings, catalogue cuts, material date sheets, maintenance manuals, etc. Organize the descriptive submittals in a chronological order of their submittals. Refer to Chapter 2.6.4, Descriptive Submittals, for more information.

2.13 Required Document Quantities for Title I, II, and III

The number of documents to be submitted to Facilities Engineering for review at Title I and Title II and for reference at Title III varies according to project scope and using organization involvement. In some instances, half-size drawings are acceptable in lieu of full-size. The number and type of drawing sets required are typically specified at the pre-negotiation conference or project-specific Design Criteria.

In all instances where the number of documents was not pre-negotiated, provide the following at each submittal:

2.13.1 Title I Review

Drawings	1 set D-size, 15 sets 11x17
Outline Specifications	8 sets
Estimate and Analysis	5 sets
Energy Conservation Report (as specified in the Design Criteria)	5 sets
All electronic files	1 set disks

2.13.2 Title II Review

Drawings	6 sets D-size, 10 sets 11x17
Specifications	10 sets
Design Analysis Estimate	8 sets
Energy Conservation Report (as specified in the Design Criteria)	5 sets
All changed and new electronic files	1 set disks

2.13.3 Title III (Exclusive of Bid Sets)

Drawings	2 sets D-size, 6 sets 11x17
Specifications	8 sets
All changed and new electronic files	1 set disks

2.13.4 Post-Title III

Drawings, as-built	5 sets 11x17, 1 set disks
All changed and new electronic files	1 set disks

Facilities Engineering shall return Title I review marked-up documents for use during Title II. When submitting Title II, the A/E shall return the Title I markups to the SDR, who will return Title II markups for use in making final corrections to the bid documents. The A/E shall then return Title II markups along with original drawings for sign-off by the SDR.

2.14 Quality Assurance

For each major project (typically line items and above), the Sandia/NM Project Manager is responsible for developing a QA plan as defined in the Design Criteria. The degree of risk identified in the project's risk assessment plan will determine the extent of the QA plan. Typical elements of the plan include but are not limited to design documents review and control, construction documents review and control, construction tests and inspections, change order review and control, facility acceptance and transfer, and completed project documents distribution.

Personnel in the following departments in addition to the customer should be provided the opportunity to review and provide comments in their area of expertise for projects as applicable:

- Corporate Projects or Customer Projects (Sandia/NM Project Manager)
- Sub-sites Management (Building Management, Fire Protection)
- Facilities Environment, Safety, and Health (ES&H) (Safety, Industrial Hygiene, Radiation Protection, Asbestos/Lead Abatement)
- Planning and Project Development (Architecture)
- Electrical and Structural Systems Engineering
- Mechanical and Civil Systems Engineering
- Facilities Express (Elevators and Cranes/Hoists)
- Electrical Maintenance Services (Electrical Systems)
- Mechanical Infrastructure (Mechanical Systems)

- Site Operations (Building Mechanics, Facilities Control System)
- Customer Projects (Roofing)
- Structural Services (Door Hardware)
- Grounds and Roads Services (Landscaping, Irrigation, Roads)
- Custodial Services
- Construction Inspection and Acceptance
- Physical Security
- Electronic Security
- Telecommunications Operations
- Transportation (Loading Docks)
- Receiving (Docks and Receiving Rooms)
- Mail Services
- Hazardous and Solid Waste
- ES&H Customer Support Team (Line-Specific ES&H Issues)

Documentation of the quality assurance process is initiated and maintained by the Sandia/NM Project Manager. The A/E may be delegated to host part of the process as part of their task.

2.14.1 Facilities Management and Operations Center Quality Assurance Review Process

Line Item Projects, General Plant Projects, expense-funded projects with a construction budget of $250,000 or more, and specific projects with unique ES&H requirements require a multi-departmental QA review including the customer as well as the applicable departments listed in the previous section. This review is typically performed during the development of the Conceptual Design Report and the Design Criteria, and with the submittal of the Title I (approximately 30 percent completion) and Title II (100 percent completion) designs. The intent of the review is to ensure that the required percent of the design is complete and compliant with all applicable codes and orders. The reviews should also confirm that the customer's requirements are satisfied in the most cost effective manner. This review does not relieve the A/E of performing their required internal reviews prior to submitting their work to Sandia/NM.

There are a number of ways to conduct an effective QA review. This includes the Sandia/NM Project Manager sending the documents to all of the reviewers, providing the documents in a central location at designated times, holding a workshop with the reviewers to present the project and solicit comments, or a combination of these. The Sandia/NM Project Manager shall determine the most effective method to conduct the reviews considering the project budget and schedule. In all instances it is important for the Sandia/NM Project Manager to provide notice to the reviewers of the impending review, and to provide a sufficient amount of time for review.

2.14.2 Design Package Quality Assurance Review

The FMOC Design Package Quality Assurance Review Form (FDPQARF) is initiated by the Sandia/NM Project Manager and delivered to the Reviewer(s) to record his or her comments. The reviewers shall mark all comments on the FDPQARF because these sheets serve as the permanent record of the review. After reviewing comments, the Sandia/NM Project Manager shall provide a written response back to the reviewer on all comments. Reviewers' comments that are adopted in their entirety are so noted on the FDPQARF. If a comment is not adopted or

is adopted with exceptions, the Sandia/NM Project Manager will note the action and the reason for exception on the FDPQARF or on an attached sheet, which is then returned to the reviewer. The project design team shall meet with the reviewers, individually or as a group, as needed to discuss the comments or to resolve any disagreements.

After all comments have been reviewed, the Sandia/NM Project Manager is responsible for resolving conflicting comments and consolidating the responses into a single electronic document to be returned to the A/E.

2.14.3 QA Process and A/E Liability

The QA Process is a tool to assist the project in finding errors, omissions, etc. However, the absence of comments on a specific issue from Sandia/NM does not release the A/E from fulfilling all contractual requirements.

2.15 Project Close-out

The Sandia/NM Project Manager is required to participate in elements of the project closeout. These elements include but are not limited to Facility Acceptance, Final Cost Report Process, Contracts Close-out and Contractor Evaluations, and Record files.

2.15.1 Facility Acceptance

The project design team shall participate in the final construction walk through, preparation of as-built drawings, and completion of documentation.

2.15.2 Final Cost Report Process

2.15.2.1 Overview

This process establishes policies, procedures, responsibilities, and guidance for the preparation of Line Item Project and General Plant Project (GPP) Cost Reports. The Final Cost Report on a construction project should be completed as close to the date of beneficial occupancy as possible but not to exceed six months after the facility is in service. Beneficial occupancy occurs when a building or structure is occupied by the technical/administrative organization for which it has been intended, although all equipment may not be installed.

2.15.2.2 Administrative Support Office Responsibility

The following are the responsibilities of the Sandia/NM Administrative Support Office:

- Serve as the coordinator in gathering all the necessary information from the A/Es, the design engineers, the line organization, the financial system, and any others required for the timely preparation and issuance of Final Cost Reports on Line Item and GPP construction projects.
- Monitor the closing of all purchase orders related to projects that have been beneficially occupied.
- Work with the Sandia/NM Project Manager and design engineers to determine how purchase order costs should be aggregated to best fit the engineer's descriptive write-up for the Final Cost Report.
- Work with the Sandia/NM Project Manager and design engineers in preparation of their portion of the Final Cost Reports on Construction Projects. A list of all purchase orders applicable to the project along with the associated cost will be provided.

- Provide the design engineers with suggested format and cost breakdown for their write-ups for Final Cost Reports. All Final Cost Reports are different. They cannot follow the same format used for constructing a new building. The Administrative Support Office has on file several Final Cost Reports that have been accepted by the DOE Office of Kirtland Site Operations (DOE/SSO), and will provide examples to use as a format guide.

  Note: Final Cost Reports consisting of only a single paragraph have always been rejected by DOE/SSO. The reports require a breakdown of the construction elements for input into the Real Property Inventory System as well as for capitalization into the Sandia/NM accounting system.
- Finalize preparation of the Final Cost Report and transmittal letter to DOE/SSO.

2.15.2.3 Sandia/NM Project Manager's Responsibility
The following are the responsibilities of the Sandia/NM Project Manager:

- Complete the Final Cost Reports with the assistance of the Systems Engineers.
- Work with the line organizations and provide the Business Office with equipment write-ups and/or listings for equipment procured by them with Line Item construction funds. The Administrative Support Office provides the purchase order listing for this exercise.
- Provide explanations as to cost and schedule variances as compared to the original directive.
- Verifies the Sandia Project Team has received all final project files.

2.15.2.4 Sandia/NM Line Organization's Responsibility
The line organization works with the Sandia/NM Project Manager in providing the Administrative Support Office with equipment write-ups and/or listings for equipment procured by them with Line Item construction funds.

2.15.3 Contracts Close-out and Contractor Evaluations
The project design team shall participate in the performance evaluation of the design and construction contractors as shown on Standard Forms 1420, Construction Contracts, and 1421, Architect-Engineer.

2.15.4 Record Files
The Sandia/NM Project Team shall participate in the handling of the project records, as directed by the Sandia/NM Project Manager for permanent retention to the following:

- Operations
- Maintenance
- Configuration Management
- Quality Assurance.

2.16 Safety Requirements
The Sandia Project Team members, including Project Managers, Building Managers, Architects, Engineers and other Design Professionals, shall incorporate safety into all project designs to meet OSHA 1910, 1926, and Sandia National Laboratories' corporate requirements

for fall protection. All safety related portions of a design, including design drawings, specifications, code analysis and calculations, shall bear the seal, signature, and date of a New Mexico-licensed Design Professional as required and regulated by New Mexico's State Board of Licensure for Professional Engineers and Surveyors, and its Board of Examiners for Architects.

2.16.1 Fall Protection Design Requirements for Roof Top Parapets.
All roof top parapets shall be 42" minimum above the finished roof surface to the top of the coping cap. Railing or other means of fall protection like tie-offs will not be acceptable unless they meet the current OSHA requirements and Project Team requirements. See OSHA 1910 and 1926 for other fall protection requirements that may apply.

2.16.2 Fall Protection Design Requirements for Sloping Roofs.
For all sloping roofs, fall protection design shall incorporate an engineered solution for tie-offs or railing and must meet the current OSHA and Project Team requirements. See OSHA 1910 and 1926 for other fall protection requirements that may apply.

2.16.3 Fall Protection Design Requirements for Skylights.
The design of all new buildings, additions and renovations with skylights shall include provisions for fall protection that incorporate an engineered solution to meet OSHA. See OSHA 1910 and 1926 for other fall protection requirements that may apply.

2.16.4 Fall Protection Design Requirements for Roof Hatches, Stairs and Ladders.
The design of all new buildings, additions, and renovations shall include an engineered solution for a roof access hatch, roof access ladder or roof access stair that meets OSHA and the Project Team requirements. See OSHA 1910 and 1926 for other fall protection requirements that may apply.

- End of Chapter -

Chapter 3 - Civil Design Standards

3.1 Introduction

This chapter presents the criteria, standards, and regulations for the design of Civil systems at Sandia/NM. It does not cover the criteria necessary for all major system facilities. The material is directed to the competent design professional and is not intended to be a detailed design handbook. Criteria and standards presented are those determined to be the minimum acceptable values necessary to result in system designs having satisfactory functional characteristics, durability and operational suitability. It is expected that the designer will strive for the best design to suit the circumstances involved, and the designs will reflect sound professional judgment at all times. In addition, the designer is expected to coordinate design efforts with other project discipline design team members in support of the integrated whole building design approach (see Chapter 2.2).

The following minimum design standards are applicable to the civil work phase on all projects. For general requirements associated with all phases of the project, see Chapter 2, General Design Standards and Procedures.

For a list of accepted standard construction specifications, standard details, and design guides, see Attachments 3.A and 3.B. References shall be used as indicated in this Manual.

3.2 Construction Drawings

3.2.1 Area Map and Vicinity Map

A area map shall be made for the purpose of showing a "zoomed" out view of the project site in relation to its location on Kirtland Air Force Base. The area map shall have a scale of 1 inch = 1 mile or larger.

In addition to the area map, prepare a vicinity map to a maximum scale of 1 inch = 200 feet, or as otherwise directed by the Sandia Delegated Representative (SDR). Where applicable, show haul routes, disposal areas, security checkpoints, major street names, and other pertinent information.

3.2.2 Plans and Profiles

Prepare plan and profile sheets for the following:

- Water (domestic and fire protection), storm drain, sanitary sewer, gas, chilled water loops, and recycle/recovery loops.
- Steam and condensate lines
- Electrical overhead and underground electrical >600 volts.
- Other large cables when pulled into long raceway runs.
- Road construction and paving improvements, including utilities within roadways.
- All ductbanks and buried conduit.

Profiles shall have an expanded vertical scale and show the line continuous in profile with break lines to show change in direction, if necessary. Run all stationing on plan and profile sheets from left to right regardless of the direction of the north arrow. Draw associated plan views to detail portions of the plan not adequately detailed on the plan portion of the plan and profile.

Prepare plans, profiles, or cross sections to adequately describe paving improvements and extensive grading work. Where appropriate minor grading and shaping can be shown on a site plan by spot elevations.

3.2.3 Site Plans

Prepare site plans to a scale of 1 inch = 20 feet, unless otherwise noted in the Design Criteria, and orient the plans as listed in the Facilities CADD Standards Manual. Show coordination relating to existing underground utilities, architectural, mechanical, landscaping including vegetation and irrigation lines, and electrical items on all site plans to guide trenching and excavation. Locate the existing underground utilities in the construction area as accurately as practical.

Do not rely solely on Sandia/NM's GIS mapping for accuracy. As a minimum the design team shall utilize the GIS maps with a site visit to verify accuracy of the information. The design team shall collect critical measurements during their site visit.

Provide additional utility location methods such as line spotting, potholing, excavation, or ground penetrating radar as required to properly design the project.

3.2.4 Underground Utilities

Add the following note to the general notes section of the title sheet for projects that include existing underground utilities work:

"Caution When Excavating

The locations of all underground utilities shown are approximate. The contractor shall verify the horizontal and vertical location of all underground utilities prior to the start of construction. The contractor shall not interfere with utility line operations and shall coordinate all work affecting existing utilities with Sandia/NM for each utility and shall notify the Sandia/NM Construction Management Engineer (CME) promptly of any problems or conflicts encountered. Further, the contractor shall notify the construction inspector prior to start of excavation and obtain a digging permit. See specifications for other requirements."

3.2.5 Drawings Required for Construction

The following sections provide lists of drawings required for the typical job. To illustrate the scope of a project, an approximate list of the plans and drawings required is provided in the Design Criteria for each discipline. If a project does not have Design Criteria see Chapter 2, General Design Standards and Procedures, for information on drawing organization and arrangement of the overall construction drawings set. Graphics files for all projects shall conform to the requirements indicated by the Facilities CADD Standards Manual. Civil

drawings and organization within the construction drawings set include but are not limited to the following:

1. Title Sheet: Include job title, project number, contract number, vicinity map, and index of drawings. (If the index is extensive it may be placed on a separate "Index of Drawings" sheet.)
2. Vicinity Map: Map showing a zoomed-out view of the project site in relation to its location on KAFB at a scale of 1 inch = 1 mile or larger (may be combined with Title Sheet or Site Plan for small jobs).
3. Site Layout Plan: Show general notes, limits of construction, fence, access, storage areas, street names, and the alignment of temporary fencing that encloses the work areas, etc. Provide Sandia/NM control monuments with ties to new construction.
4. Removal or Demolition Plan: Show all existing facilities to be removed and pertinent phasing. If required for modifications work, include a site survey.
5. Grading Plan: Show the building(s) considered in the contract, the surrounding area, existing topography (including contours at an appropriate interval), and required elevations referenced to an existing benchmark. Show finished grading and existing grades to determine cut and fill. Show street centerlines properly referenced to the coordinate system. Show utilities, unless separate utility site plans are included in the set.
6. Drainage Plan: Show drainage basins, flow paths, rates, and finished contours unless submitted in a separate drainage report.
7. Exterior Utilities Plan: Show all existing and new utilities, including irrigation lines, where feasible. Provide a legend for all existing and proposed utilities.
8. Plan and Profile Drawings: Provide plan and profile drawings for all utilities unless otherwise directed by the System Engineer. Show the plan and profile of road construction, as well as survey data and the existing grade at centerline (not required for short access or service drives). Show the plan and profile of new utilities as well as the existing and finished grades at centerline.
9. Detail Sheets and Area Plan(s): For road construction, show typical roadway cross-section, intersection plan with spot elevations as needed, turnouts, special paving area plans, pavement section details, and structure details.
10. Cross-Section Sheets: For road construction, cut and fill cross-sections at specified stations when requested by the SDR.
11. Exterior Civil Details: Provide reference to standard details or show details for civil site work. All details must be labeled descriptively, and cross-referenced to the applicable Plan drawings. See the CADD Standards Manual for additional CADD requirements. See Attachment 3.B for a list of approved standard drawings.
12. Site Planting and Irrigation Plan(s) and Details: Show all required information on separate sheets. Follow the guidelines listed in applicable sections of the Sandia/NM Campus Design/Development Guidelines.

3.3 Site Modification Review Process

All site modifications must follow the Site Modification Review Process, Procedure No. AP-004. The process document, with its attachments, outlines the requirements for this procedure. All

utility connections must be submitted on a site plan to Facility Systems Engineering for approval.

3.4 Exterior Utilities

When designing exterior utilities, take into account possible future extensions and utility demands. The Sandia/NM Project Team shall provide direction to size utilities for future demands. Size utilities to accommodate future connections. In general, if expansion is planned, extend utilities to the edge of the site or to a point where connection can be made without damage or disruption to the utility or adjacent structures. Establish utility corridors with each utility having a defined location within the corridor to optimize land use and provide adequate utility separation. The design engineer shall consult with the Facilities System Engineers during conceptual design to ensure proper connections and sizing. The Facilities System Engineering Departments will consult with the Facilities Planning and Project Development Department to ensure proper location in regard to future construction.

The Facilities System Engineer responsible for each system shall review and approve all connections to the system in the preliminary and final design phase.

3.4.1 Underground Water Lines for Domestic and Fire Protection Systems

Water line design shall conform to the criteria listed below. The Sandia/NM Facilities Water System Engineer shall approve in advance any departure from the criteria.

- All water lines and their connections to existing water lines shall be designed and shown on a plan and profile drawing. Drawings shall show all details including required fittings and joint restraints.
- All lines 6 inches or larger shall be cement-lined ductile iron pipe in accordance with Sandia/NM Construction Standard Specification and standard drawings (see Attachments 3.A and 3.B). PVC pipe is not allowed for lines 6” or larger in diameter.
- Size water mains per requirements from the Facilities Water System Engineer and Fire Protection Engineer. Each branch off the main water line shall have a gate valve in a yard box to isolate the building or facility from the main. Where possible the potable water service shall be a branch off the fire service line, with its own gate valve in a yard box.
- Minimum depth of cover shall be 36 inches.
- The trench for pipe installation shall be similar to Type 4 as defined by American Water Works Association (AWWA) C600. Pipe bedded in 4 inches of sand, gravel, or crushed stone. Backfill shall be compacted to the top of the pipe to approximately 80 percent Standard Proctor, American Association of State Highway and Transportation Officials (AASHTO) T-99.
- Unless approved by the Facilities Systems Engineering Department, connections larger than 2 inches shall be made by cutting the supply main and inserting a standard tee. The maximum allowable tap using a tapping saddle is 2 inches. When approved by the Facilities Systems Engineer for connections larger than 2 inches, tapping sleeves shall be used. Only tapping sleeves are allowed for PVC pipe. See Facilities Construction Standard Specification 02665 for additional tapping requirements.

- When the water main supply line is 8 inches or larger the minimum size fire protection line shall be 8 inches for any sprinkler system supplying a building designed for Ordinary Hazard Group II or greater. Buildings, T-Buildings, Mobile Offices, and Trailers smaller than 10,000 square feet are exempt from the 8-inch minimum fire line requirement. Fire protection mains shall not be run under buildings, including temporary structures, such as mobile offices or trailers.
- Locate post-indicator valves (PIVs) on fire protection lines no closer than 40 feet and no farther than 100 feet from the building. If this distance is not feasible, the Facilities System Engineer may grant authority to locate PIVs at different distances. Indicator-post supervisory switches shall be installed for all PIVs and connected to the building fire alarm system. The devices shall be electrical; single-pole, double-throw, with normally closed contacts and include design that signals controlled indicator-post valve is in other than a fully open position.
- Three-way fire hydrants with a curb box valve shall be provided within 50 feet of all fire department connections. Fire hydrant spacing shall not exceed 300-foot intervals. Sandia/NM shall determine fire hydrant spacing in remote areas and on transmission lines.
- All pipes passing under railroad tracks shall be encased in a protective metal sleeve, sized at least 2 inches larger in diameter than the waterline. Support the pipe in the sleeve per manufacturer's instructions. Seal the ends of the sleeve with resilient caulking material or a preformed plastic boot.
- Mechanically restrained joints shall be designed and detailed on the construction drawings. See Sandia/NM standard drawing WU5005STD (old #101630/A5).
- The design of valving within the water system shall conform to the following criteria:

  A. Valve Spacing
     - 2,600 feet maximum between in-line valves for lines 16 inches and larger.
     - 1,200 feet maximum between in-line valves for lines 14 inches and smaller.

  B. At the intersection of water lines, all lines shall be valved.

  C. Fire hydrant legs from mains shall be valved.

  D. Valve Location: Avoid locating valves under parking spaces or locations where the valves may be covered up.

  E. Valve Types:
     - Valves 12 inches and smaller must be gate valves.
     - Valves 14 inches and larger must be butterfly valves.

  F. Valve Sizing:
     - All valves shall be the same size as the main lines.

  G. Air Relief Valves
     No air relief valves or air relief hydrants are required on lines 8 inches or smaller where there are services on the line. On distribution lines greater than 8 inches,

sizing and location of air relief hydrants must be coordinated with the Facilities Water System Engineer.

3.4.2 Sanitary Sewer

This section presents the criteria, standards, and regulations for the design of sanitary sewer systems. It does not cover the criteria necessary for design of major interceptor sewer, lift station, sewer line rehabilitation, or wastewater monitoring facilities.

3.4.2.1 Septic Tanks and Dry Wells

If a sewer main is not economically feasible, install a holding tank. Do not design holding tanks for flows greater than 375 gallons per day. Holding tanks should be accessible and capable of supporting wheel, backfill, and other loads if buried.

Septic tanks and dry wells shall not be used without the written consent of the Sandia/NM Environmental Operations.

3.4.2.2 Engineering Design Criteria

Design sanitary sewers to maintain velocities that will provide self-cleaning action. See the table in Section 3.4.2.4 for minimum slopes that provide minimum velocities. Avoid velocities above 10 feet per second because of possible long-term damage to the pipe. New facility sewer connections located several hundred feet from the existing system should provide capacity for future expansion. At all horizontal changes in the alignment, provide manholes in lines that are 8 inches or larger.

Designer shall ensure by visual inspection, drawing research, field survey, and/or dye testing that plumbing connections are made to appropriate sanitary sewer piping. Do not make piping connections that result in the flow of sanitary sewer to the storm drain system, and do not connect storm drains to sanitary sewers.

3.4.2.3 Manhole Criteria

1. Avoid locating manholes in natural or manmade drainage swales and parking lanes and spaces.
2. Standard minimum manhole depth is 6.0 feet, measured from the rim to invert. The Facilities System Engineer must approve deviations.
3. The required inside diameter for a manhole is determined as follows:
   a. Minimum inside diameter is 4.0 feet.
   b. A minimum 9-inch-wide shelf must be provided on each side of each main line within the manhole.
   c. Where the main flow changes direction at a manhole, the manhole must be large enough so that the centerline radius of curvature of the flow invert will be larger than the pipe diameter.
4. Flow will not be permitted to change horizontal flow directions by more than 90 degrees in a manhole.
5. Invert elevations will be called out for each inlet and outlet at a manhole.
6. Drop across manholes will be provided as follows:
   a. Where the main flow does not change direction at the manhole, the design will provide:

i. A slope across the manhole at least equal to the average of the slopes of the incoming and outgoing lines.
ii. The minimum drop will be 0.05 feet for lines 36 inches and smaller

b. Where the main flow changes direction at the manhole, the design will maintain the average of the slopes of the incoming and out-going lines and compensate for the loss of velocity head caused by the turn.
   i. The slope component will be equal to the average of the slopes of the incoming and out-going lines times the diameter of the manhole.
   ii. The velocity head component will be determined by the following formula:

$$h_b = K_b(V^2)/2g$$

Where:
h_b = required drop to compensate for loss of velocity head (feet).
K_b = bend coefficient, use 0.4 for 90 degree turn, 0.32 for 45 degree turn and linear proportioning for other deflection angles (dimensionless).
V = design velocity of incoming line based on design flow, feet/sec.
g = 32.17 feet/sec^2

   iii. The total drop required through the manhole will be the sum of the slope component and velocity head component.
   iv. The minimum drop through a manhole will be 0.10 feet.

c. Where flows converge at a manhole, the inverts should be designed to produce a smooth water surface at design flow with no backwater conditions in any of the incoming lines. Excessive drops that cause turbulence are to be avoided.
d. The use of drop connections to manholes (drop manholes) will require Facilities Engineering approval: drop manholes shall conform to the Standard Drawings (see Attachment 3.B).

7. Drop manholes and other manholes with high potential for sulfide gas generation must be designed with corrosion resistant coating such as epoxy on interior walls, when directed by Sandia/NM Facilities System Engineering.
8. The maximum distance allowed between manholes is 450 feet.
9. When an interim line extension is to be built for a distance less than the reasonable spacing for a manhole installation, the Facilities Engineer may allow installation of a "temporary", 8-inch diameter, end of line cleanout, in lieu of a manhole. The design drawings for such installation must provide a design to the next anticipated, upstream manhole location, with line and manhole beyond the temporary cleanout depicted as "Future".

3.4.2.4 Line Criteria

1. Minimum service connection size allowed: 6-inch inside diameter. Minimum mainline size is 8 inches. Sanitary sewer materials shall comply with the requirements of the specifications and standard drawings.
2. Following are minimum slopes considered necessary to provide minimum allowable velocities of 2 feet per second at 50% full and n = 0.013. Greater slopes than minimum

are desirable and are to be provided where possible. Maximum slopes should never result in supercritical flow.

Sewer I.D. (inches)	Minimum Slope (feet/foot)
6	0.0060
8	0.0060
10	0.0028
12	0.0022
15	0.0015
18	0.0012

3. Sections of line between manholes that are flat relative to the upstream line are to be avoided. Continuous flow velocity and capacity should be provided as much as possible.
4. Line depths should be sufficient to provide gravity service contiguous to the line. Additional depth may be required to provide gravity services where buildings are located far from the line.
5. The main lines are to be located within established utility corridors or as directed by the Facilities System Engineer.
6. The New Mexico Environment Department policy on the proximity of water and sewer lines, with City Amendment as follows:
   a. Main lines must be located so that they can be maintained without disturbing any building, structures, sidewalk, curb and gutter, or other utilities. **In no case shall buildings or structures, temporary or permanent, be built over a sanitary sewer collector/interceptor or other utility lines.**

3.4.2.5 Service Connections Criteria

1. Service connections must be made to the mainline except at the end of the main where connection to a manhole is permitted in the manner shown in the standard detail drawings (see Attachment 3.B).
2. Service connections to a manhole are to be made with the invert of the service at the top of the main line.
3. Service connections to mains will be constructed as follows:

Service Size	Main Size	Connection Method
4 inches	8 inches	Insert manufactured tee/wye or Core drill main and install saddle
6 inches	8 inches	Insert manufactured tee/wye or Install manhole
6 inches	10 inches and greater	Insert manufactured tee/wye or Core drill main and install saddle
8 inches	8 inches and greater	Install manhole

4. Drop connections at manholes shall be constructed as shown on “Standard Drawings.”
5. Service connections shall be made such that the service is perpendicular to the sewer main unless a manufactured wye is installed.

6. All service connections shall have a minimum slope of ¼ inch per foot toward the main and shall have a minimum depth of 4 feet below the finished surface at the connection to the building.
7. Double cleanouts shall be placed a maximum of 100 feet along the service line. Single cleanouts shall be installed at all horizontal bends a minimum distance of 5 feet away from the face of the building. Cleanouts shall be constructed in accordance with the standard drawings (see Attachment 3.B).

3.4.3 Natural Gas

Use polyethylene pipe for all new underground gas in accordance with Facilities Construction Standard Specifications and Standard Drawings (see Attachment 3.B). Design gas distribution to meet local codes and requirements. Natural gas in the Albuquerque area has a higher heating value of approximately 850 BTU per cubic foot (referenced to 12.12 psia). The distribution grids in Tech Areas I, II, III, IV, and V are set for approximately 20 psig nominal. Select regulator at building for pressures as low as 15 psig to allow for sag during peak usage, and capable of withstanding pressure as high as 60 psig in the event that higher distribution pressures are required in the future. Consult with the Sandia/NM Gas System Engineer for planning and system modeling of all gas distribution work. The Sandia/NM Gas System Engineer shall size all distribution piping using Stoner Gas modeling software based on input from the designer. (Designer may size individual building run-outs.) The designer shall size piping past the regulator using the International Fuel Gas Code tables. Obtain approval from Sandia/NM Gas System Engineer and Fire Protection Engineer to use gas pressure exceeding 14 inches water gauge inside the building.

Install regulator/meter assembly outside the building in accordance with Sandia/NM Standard Drawings. The regulator shall be spring type with built-in relief provisions, insect screen and shall be protected from vehicles. Do not use pilot regulators since they are prone to lock-up during freezing weather. Diaphragm meters with electronic temperature and pressure compensation and automatic reporting of monthly total and peak gas flow via the Facilities Control System are preferred. Odometer type displays are preferred over dials. Obtain approval from Sandia/NM Gas System Engineer prior to using rotary or turbine gas meters. (Rotary meters are subject to lock-up and turbine meters have turndown limitations.) Size components for 12.12-psia local atmospheric pressure.

Use an anode-less riser followed by an insulating union to electrically separate the above ground and below ground gas systems in accordance with Sandia/NM Standard Drawings. Do not use metallic piping, valves or other underground components that require cathodic protection or other maintenance. Provide valve clusters at all major piping intersections.

Refer to “Gas System Summary” located on Sandia/NM server “Paris\Sys Eng\Building System Summaries\Infrastructure” for a system description.

3.4.4 Liquefied Petroleum Gas

Use liquefied petroleum systems for relatively small buildings in remote areas. Stamp storage tanks with the American Society of Mechanical Engineers’ Boiler and Pressure Vessel Code Symbol, and a National Board Number. Consider the local ambient temperatures that determine

how much of the tank's capacity may be safely filled with liquid. Size the tanks for 30-day storage for the maximum degree-day. Consider the composition of the liquid commonly distributed in that area during winter.

Locate a regulator, relief valve, capacity gauge, and fill valve under a protective cover on top of the tank. The exterior regulator shall have automatic shutdown devices for excess flow conditions. Take care in sizing lines and regulators so freeze-up will not occur due to the refrigerant action during cold weather. Specify an American Gas Association 100-percent shutoff safety pilot and appliance regulator on all appliances.

3.4.5 Storm Drain

Storm drain design shall comply with the design portions of Chapter 22 of the City of Albuquerque Development Process Manual, Latest Edition (see Attachments 3.A and 3.B for a list of approved design guidance, specifications, and standard drawings). The applicable technical guidance includes the following sections:

- Hydrology
- Hydraulic Design
- Channel Treatment Selection Guidelines
- Design Grading and Erosion Control
- Miscellaneous.

See Chapter 3.6, Drainage Requirements.

3.5 Site Work

3.5.1 Grading

Prepare a current topographic survey for all new construction projects when grading or trenching is required. The topographic survey shall be tied into the Sandia/NM Survey Control Monuments for establishing x, y, and z (see Chapter 3.7, Surveying). Topography should strongly influence project design. Plan facilities to fit the topography with a minimum of grading and to preserve the site character in an efficient and economical manner. Site grading shall minimize site disturbance by emphasizing conservation of existing natural areas and restoration of previously damaged areas.

In the site grading design provide for adequate surface drainage and preservation of natural terrain by allowing a minimum of earth movement with the objective to balance between cut and fill. To prevent surface drainage from entering or ponding adjacent to the structure, place finished floor elevations with access penetrations sufficiently above the existing ground gradient or the roadway grade. Write an accompanying drainage report to prove these criteria (see Chapter 3.6, Drainage Requirements).

In the site grading design, take into account the need for safety and ease of personnel and vehicular access to the facility. The accessibility to facilities is required for physically handicapped persons in accordance with the Sandia/NM Campus Design and Development Guidelines and ADA requirements.

Design the outside finished grade to slope away from the building at a 5-percent grade for the first 10 feet unless otherwise approved by the Facility System Engineer (FSE). Extend the 5-percent grade to 20 or 30 feet in areas with highly expansive soil. When site conditions require the use of steep slopes near buildings, provide a berm that is at least 6 feet wide at a 5-percent grade to the building. Indicate these requirements on the grading plan with critical spot elevations and finished contours. When the adjacent outside grade is brought above the building floor level for energy conservation, aesthetic, or economic reasons, design the outside finish grade to slope away from the building at a 20-percent minimum grade for at least 5 feet.

A topsoil Surface Disturbance Permit is required for any soil disturbance activity affecting a land area greater than 3/4 acre. Soil disturbance is defined as any activity that disrupts, moves, removes, or adds to the soil and is calculated as the total surface area of the land affected. Include the quantity of soil disturbance in the construction contract. See Chapter 3.6.2, National Pollutant Discharge Elimination System Permitting Requirements, for additional information.

3.5.2 Fencing

Design fencing to provide security for the assets and/or property protection, as required. Chain link security fencing shall be designed in accordance with Sandia/NM standard drawings. Standard security fencing is installed over paved surfaces or stabilized soil with the bottom rail within 2 inches of firm ground. Buried security fencing is used over unpaved areas where the fence fabric and bottom rail are required to be buried 6 inches below grade. Temporary fencing may be used to separate construction areas from controlled areas for safety and security purposes. Temporary fencing requirements will depend on the site location. In general, temporary fencing may be less rigid in its construction based upon location of the fence, duration of use, and any other contributing security or environmental factors. A review by Physical Security is required prior to erecting, moving, or removing any fence. See Attachment 3.A and 3.B for a list of Specifications and Standard Drawings.

Fences used for security purposes shall be 11 gauge and topped with three strands of barbed wire on single or double outriggers. Where soil stabilization is not possible, concrete curbs, sills, or other anchoring devices extending below ground may be used. The fence will be a minimum of 8 feet above surrounding grade.

Temporary fencing may be used for the protection of a security area with the concurrence of a Physical Security representative.

Fire Department access must be provided during construction and occupancy phases when designing temporary and permanent fencing.

Use swinging gates in fencing where possible. When rolling gates are required, use a system with an overhead support, if practical. If a cantilevered gate must be used, use a system with an enclosed top rail as a track. Avoid using rollers at grade because dust and water accumulations are a constant maintenance problem. Gate hardware for security fencing shall be brazed, peened, or welded to prevent removal.

Locate security fencing a minimum of 20 feet from structures or assets located inside the security area and a minimum of 20 feet from structures located outside the security area. Always consult

with a physical security representative for the latest standoff information and specific security requirements for specific areas.

3.5.3 Sidewalks

Design sidewalks and walk gradients to provide safe and convenient access, egress, and circulation between facilities. Base the width of sidewalks on anticipated traffic, with a minimum width of 4 feet increasing in 2-foot increments. Sidewalks paralleling curbs in parking areas and those with high pedestrian use shall have a minimum width of 6 feet. All sidewalk widths shall be consistent with handicapped accessibility requirements. Provide ramps where required for access. A ramp must be used when sidewalks exceed a 5-percent slope.

Integrate sidewalk design with drainage system and landscape design as much as possible to promote collection, conveyance, and infiltration of storm water runoff generated from continuous, impervious sidewalk surfaces. In addition, prevent sidewalks from contributing to heat island effects by providing shade from landscaping or locating sidewalks in areas not subject to sustained sunlight.

3.5.4 Dual Bicycle and Cart Paths

Bicycle/cart paths shall be provided separately from pedestrian sidewalks, when requested by the SDR. The paths shall have a minimum width of 12 feet, a maximum transverse slope of 5%, and a maximum cross slope of 2%.

3.5.5 Roads

The criteria for road design shall be in accordance with AASHTO's, A Policy on Geometric Design of Highways and Streets, latest edition. When designing roads and associated drainage systems, take into account soil, geologic, topographic, and climatic conditions, including any special conditions such as snow removal. Roadways shall be designed to accommodate the maximum size of vehicles traveling through the area. During planning and design, carefully consider the timing of road construction, specifically in regard to seasonal conditions. Flexible pavements and curb and gutter shall be in accordance with approved standard pavement drawings (see Attachment 3.B).

If required, perform studies to estimate the volume and character of traffic during both the construction and operating phases. Controlling vehicle speed within congested areas can permit the profile of roads to conform generally to the ground surface, which allows maximum use of adjacent areas and results in economical road construction costs. The Sandia/NM Traffic Safety Engineer shall determine speed limits. Reserve sufficient right-of-way for anticipated future expansion. Design underground utilities and plan construction to minimize interference with road construction.

Wherever feasible, place construction roads in locations and with profiles proposed for the final road system. For permanent roadway alignments create shoulders and bases that can be surfaced after construction for future roadway improvements.

Integrate road design with drainage system and landscape design. Consider landscaping and other suitable means of harvesting runoff from roads to promote collection, conveyance, and infiltration into the soil.

For environmental protection, expeditiously complete road ditches and other necessary work to adequately provide drainage and soil stabilization for roads and construction areas. In addition, carefully maintain roadways, ditches, and drainage structures during construction.

Design of emergency vehicle access shall conform to fire lane requirements defined in NFPA 1141, the International Fire Code (IFC), and the City of Albuquerque Fire Code.

The radii of intersections to the back of the curb shall be as follows:

Primary and secondary intersection	50 feet
Entrance drive:	
For private vehicles	25 feet
For large trucks, fire equipment areas, warehouse and depot areas, and fuel loading and unloading areas	50 feet
Secondary street intersections and other areas	30 feet

3.5.6 Parking

Locate parking areas to blend into the background of the building complex without detracting from the principal structures. Avoid siting parking areas in front of buildings and at prominent visual points of approach. Provide accessibility for the physically handicapped. Provide for special parking with space designators and emergency access according to the Sandia/NM Landscape Master Plan and Sandia/NM Facility Campus Design/Development Guidelines. Emphasize attractive features and de-emphasize or obscure undesirable features when designing landscaping, grading, and locations.

Parking system design must be integrated with the drainage system design and landscape design. Parking systems should be designed to minimize generation of storm water runoff, harvest storm water for landscape irrigation, and prevent the formation of heat islands. Avoid large continuous parking areas that generate storm water runoff and become heat islands during summer months. Consider smaller connected parking areas separated by landscaping that provides runoff management. Include landscape provisions (in the form of trees) to ensure that at least 30 percent of parking areas are shaded within 5 years of project completion.

Provide perimeter concrete curbs and gutters for all parking areas and access drives in built-up areas. Consider directing runoff to infiltration areas such as medians or adjacent planting areas. Such water harvesting areas must be designed and planted to accommodate occasional flooding. Direct storm water runoff into the storm drain only when the capacity for onsite management is exceeded. In remote or infrequently used areas, use concrete curbs and gutters only when required to control drainage. Use removable, prefabricated, reinforced concrete wheel stops for asphaltic concrete pavements instead of painted parking stalls.

To provide positive surface drainage, design pavement grades with

- 1/2-percent absolute minimum slope in the direction of drainage; use greater slopes wherever possible

- 5-percent maximum slope in all directions for bituminous or concrete surfaces
- 2-percent maximum slope in all directions for handicapped accessible parking spaces and access aisles.

During planning and design, consider the following factors when determining vehicle parking requirements:

- Occupancy of the facility to be served
- Provisions for physically handicapped persons
- Preferred parking for carpools and vanpools
- Service vehicle and visitor parking needs
- Single facility parking areas versus joint-use parking for adjacent facilities
- Aesthetics (siting, landscaping)
- Location of fire protection devices (hydrants, pumper connections) and accessibility for emergency vehicles
- Facilities for motorcycle and bicycle parking
- Garbage truck access
- Provisions for pedestrian traffic
- Appropriate distance from perimeter fencing (see Chapter 11, Security Design Standards).

3.5.7 Landscape

Provide landscaping according to the Sandia/NM Facility Campus Design/Development Guidelines. Landscape development should enhance the overall exterior appearance of buildings while emphasizing low water usage, minimal maintenance, and native plant materials.

When choosing and locating species of trees, ensure, as much as possible, that they will not damage underground utility lines and adjacent surface facilities. Place landscaping so it will not interfere with maintenance and repair efforts.

Consider landscaping when designing energy conservation solutions. Proper landscaping benefits include reducing solar radiation during cooling season, heat loss from wind, and heat loss during heating season. Utilize landscaping to provide shading on buildings, parking lots, roadways, walkways, and other heat absorbing surfaces that can act as heat islands during summer months. Consider deciduous plant species near buildings that provide shading during summer months and allow solar heat gain during winter months.

Consider landscaping when developing drainage system designs. Integrate landscaping with storm water management to maximize onsite containment, conveyance, and infiltration of storm water runoff. Use landscaping to minimize the generation of storm water runoff and control erosion. Incorporate rainwater harvesting to replace (if possible) or supplement landscape irrigation requirements. Use high-efficiency irrigation systems for landscapes (drip systems, moisture sensors, weather database controllers). Landscaping should be included when designing parking lots, roadways, and other surfaces that generate storm water runoff.

3.5.8 Removing Utilities

The following guidance applies when removing utilities from service or if abandoned utilities are encountered:

- If an entire site is being cleared, remove the utility within the entire confines to be cleared. If the utility extends beyond that confine and crosses sidewalks and roadways, remove the portions inside the site and abandon in place those portions off site.
- If a roadway or sidewalk is cut open for construction work and an abandoned utility is exposed (or abandoned by that project), remove exposed portions.
- If roadways or sidewalks that would otherwise not be cut would be cut to remove, then abandon in place.
- When technically feasible, use pipe bursting on sections to be abandoned in place.
- Check the system configuration to see if there are advantages or disadvantages to either removal or abandonment. For example, if there is a short piece of steel gas pipe that could either be removed or abandoned, check to see if maintenance of cathodic protection on this section could be eliminated by taking out this short additional piece. (Documentation of the cathodic protection system is poor, which makes the fieldwork to check the system very expensive. The less cathodic protection that remains in the ground the better.)
- Minimize surface disturbance to the extent practical and ensure protection of adjacent natural or landscaped areas.

3.6 Drainage Requirements

3.6.1 General Drainage Requirements

A drainage plan or report is required for all new buildings and building additions for site development projects (such as parking lots) that encompass 0.25 acres or more. Prepare a drainage and grading plan for all drainage improvements. Consider performing a drainage analysis on a case-by-case basis for smaller sites. Design engineer shall consult with the Facilities Systems Engineering Department during the conceptual phase for drainage requirements. Master Drainage Plans for Tech Areas I, II, III, IV, and V are available for review upon request.

Design the drainage system layout to best meet the operational requirements of the facility. The system should be economical and efficient while taking into consideration the topography, ultimate development of the drainage area, fully developed conditions for the basin or basins considered, outfall locations, and coordination with underground utilities. Where applicable, drainage system design should promote infiltration into the soil by incorporating provisions for on-site collection, conveyance, and containment. Consider integration of the drainage system design with other aspects of the facility design to limit the disruption of natural water flows by minimizing the generation of storm water runoff, increasing on-site containment and infiltration of storm water into the soil, and reducing contamination in storm water that must be conveyed off site. Drainage system design-integration measures that should be considered include but are not limited to:

- Roof drainage – Incorporate roof drainage into the overall drainage system design. Refrain from integrating the roof drain system with the storm drain unless no other on-site containment method is feasible (see Chapter 6.3.3.8).
- Landscaping – Incorporate landscaping features that collect, convey, contain, and promote infiltration of storm water into the soil. Include rainwater harvesting (use of storm water) in the irrigation design for landscaping (see Chapter 3.5.7).
- Parking, roadway, and sidewalk – Minimize impervious surfaces that generate storm water runoff. Minimize the use of storm drain inlets, except to accommodate overflow from on-site containment capacity. Consider separating parking rows with landscaping that can collect, convey, contain, and infiltrate runoff into the soil (see Chapter 3.5.6).

Design all new storm drainage systems to convey a 100-year, 6-hour storm. Whenever possible, drainage design shall promote on-site storm water management practices (on-site collection, conveyance, and containment), while providing for off-site conveyance of storm water (inlets to storm drain utility) that exceeds the capacity of on-site management from the design basis storm event. Design Finished Floor elevations for the 500-year event unless otherwise indicated. The design shall meet the requirements of the City of Albuquerque's Development Process Manual (DPM), Section 22, "Drainage, Flood Control and Erosion Control."

See Chapter 6.3.3.8, Drainage, for all roof drainage design requirements.

3.6.2 National Pollutant Discharge Elimination System Permitting Requirements

All construction sites that disturb an area of one (1) acre or more are subject to the National Pollutant Discharge Elimination System (NPDES) permitting requirements. Specifically, most construction projects fall under the jurisdiction of the most recent edition of the NPDES General Permit for Storm Water Discharges from Construction Activities. The permit is titled "National Pollutant Discharge Elimination System General Permit for Discharges from Large and Small Construction Activities." To determine the applicability of NPDES permitting requirements, the disturbed area associated with a construction site is defined as: "The physical location of the new facility with any utility extensions, haul roads, stockpile areas, staging areas, and any additional area disturbed by the construction."

The NPDES permit requires development of a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP must meet the applicable requirements of the National Pollutant Discharge Elimination System General Permit for Discharges from Large and Small Construction Activities. Including requirements listed in Part 3: Storm Water Pollution Prevention Plans and Part 8: Standard Permit Conditions.

Additionally, Part 8: Standard Permit Conditions requires that a Sediment Control Plan (SCP) be developed and certified by a licensed Professional Engineer as part of the SWPPP. Review Part 8: Standard Permit Conditions – C. Region 6 of the General Permit for additional guidance and requirements. Determination of soil erosion and sediment control measures included in SWPPPs will be based on the nature of the construction activities and the characteristics of the construction site.

The SCP must include site-specific interim and permanent stabilization, managerial, and structural solids, erosion, and sediment control BMPs and/or other controls that are designed to prevent an increase in the sediment yield and flow velocity from preconstruction, undisturbed conditions. Erosion control techniques for interim stabilization may include silt fencing, bale barriers, earthen berms, swales with appropriate BMP at point of discharge, sediment ponds, stabilized entrances to the construction site; or other acceptable erosion control practices. Erosion control practices for permanent stabilization may include reseeding, final site grading, and permanent surface stabilization such as paved surfaces, landscaping treatments, and graveled areas; or other engineered solutions appropriate for permanent stabilization.

Small construction sites of one (1) to five (5) acres may be eligible to apply for a waiver if the requirements in Appendix D, "Small Construction Waivers and Instructions," of the NPDES permit can be met. Additional information and guidance related to the NPDES permitting requirements can be found at this web address: http://cfpub.epa.gov/npdes/stormwater/cgp.cfm.

The A/E shall develop the SWPPP and the SCP based on the requirements of the NPDES General Permit, and submit the documents to the Sandia Project Manager (PM) for review and approval during the design phase of a project, or shall determine if Sandia is eligible for a waiver. The Sandia PM shall submit the final SWPPP to the Sandia Environmental Management Department (EMD) for review and coordination of final approval. Upon review and final approval of the SWPPP document the EMD will complete the permit process by sending a Notice of Intent (NOI) to the Environmental Protection Agency (EPA). Both Sandia and the construction contractor are required to submit NOIs. The permit does not become effective until seven days after the EPA posts the NOI on their web site.

Once the construction contract has been awarded, the contractor shall adopt the SWPPP and SCP developed for the project as required. The contractor may elect to provide their own SWPPP and SCP, but this action must be approved by SNL and the contractors SWPPP must be developed to the same standard as SNL's. Construction work shall not commence prior to meeting all of the NPDES permit requirements. Further guidance on development of SWPPPs and SCPs can be obtained from the Sandia PM or assigned Sandia Systems Engineer, as well as the EPA web site.

3.6.3 Hydrology

The hydrology criteria used shall comply with the City of Albuquerque's DPM, Section 22, "Drainage, Flood Control and Erosion Control."

Use the Precipitation-Frequency Atlas of the Western United States, Volume IV, New Mexico National Oceanic and Atmospheric Administration (NOAA) Atlas 2 for establishing design frequencies for the DBFL (see Attachment 3.A).

3.6.4 Hydraulic Design of Closed Conduits and Open Channels

Design all storm drainage systems per Section 3, "Hydraulic Design" in Chapter 22 of the City of Albuquerque's DPM. Storm drainage systems include streets, storm drains, and open channels (borrow ditches, earth channels and armored channels).

Show the flow (Q), velocity (V), hydraulic grade line (HGL), and, upon request, the energy grade line (EGL) on the construction drawings for all storm drainage systems. Keep this

information on the construction drawings and file it with the construction set for future reference.

3.6.4.1 Closed-Conduit Systems

- Design closed-conduit systems (including pipe, box, or arch sections) as flowing full and, whenever possible, under pressure, unless otherwise approved by the Facilities System Engineer.
- When designing a proposed conduit for pressure condition, do not allow the hydraulic grade line to be higher than the ground or street surface.
- Typically design lateral pipes entering a main line pipe storm drain to use standard precast wye fittings.
- The minimum diameter of the main-line conduit shall be 18 inches. The minimum slope for the main-line conduit shall be 0.005 feet per foot, and the minimum flow velocity shall be 3 feet per second during conveyance of the design flow.

3.6.4.2 Open-Channel Systems

- Construct open channels only in locations approved by the Facility System Engineer. In general, to allow for the interception of surface flows, design all open channels with the tops of the walls or levees at or below the adjacent ground.
- For unlined open channels, the mean velocity shall not exceed 3 feet per second. Determine maximum side slopes for the channel based on an accompanying soils report. In general, the side slopes should not exceed 3:1.
- When a storm drain outlets into a natural channel or unlined channel, provide an outlet structure to prevent erosion. The minimum requirements are a headwall and a wire-enclosed riprap blanket; however, the actual design should be based on the flow and velocities in accordance with the most current version of the Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) Sediment and Erosion Design Guide.

3.6.4.3 Street Drainage

- Street drainage is usually accomplished by the use of curbs, gutters, and curb inlets. Consider curb gaps in areas where roadside ditches are used. As a general rule, the streets should be clear during a 10-year storm and checked for adequate capacity during larger storms up to and including a 100-year event as defined in the City of Albuquerque DPM.
- Do not use inverted crown sections for streets without prior approval. Do not locate curb inlets in the radii of street intersections or where pedestrian traffic is most likely to occur.

3.7 Surveying

The objective of this section is to define the types of surveying and establish minimum requirements to govern the performance of survey-related services by registered professional surveyors performing work for Sandia/NM.

The survey must be established in the New Mexico State Plane Central Zone (NAD 27) Coordinate System (NAVD 29) vertical datum. Surveys shall be coordinated trough the

Facilities System Engineering, Civil Engineering Department. Surveying control data may be obtained from the Facilities System Engineering, Civil Engineering Department. The accuracy of the survey for construction, control, property, and topographic surveys shall be consistent with importance of each survey. Where required by law (i.e. applicable State Statutes) control and property surveys at Sandia/NM shall be performed by, or under the direct supervision of a professional land surveyor registered in the State of New Mexico. All survey mapping files shall be submitted in MicroStation Format (*.dgn) and shall be in accordance with the requirements outlined in the Facilities CADD Standard Manual, Chapter 7.

3.7.1 Topographic Surveys

Topographic/design surveys shall indicate the horizontal and vertical locations of **all surface features.** Underground utilities shall be shown in their horizontal location. Sanitary sewer manholes and storm drain inlets and manholes shall include vertical data based on measurements from the rim/grate to invert(s) of pipes. The locations of valve boxes, fire hydrants, post indicators, and other appurtenances for water, heating and cooling lines shall be shown, as well as power poles and clearance at sag of overhead utility lines. Underground communication lines, power lines, and other appurtenances shall be indicated. Provide all applicable information on the construction drawings.

Surveys shall be coordinated with the Sandia/NM Utility Coordinator in order to assure that underground utility lines are clearly spotted on the ground prior to commencing the survey. Line spots performed by Sandia/NM shall be in accordance with accepted standards for the color coding of utilities. Survey personnel shall be familiar with these standards and reflect the appropriate utility based on the color coding. **Pavement cuts shall not be used as an indicator of an underground utility location.**

Contour intervals shall be one foot unless otherwise specified. Sufficient spot elevations shall be provided to assure that drainage patterns are evident. The vertical accuracy of 90 percent of the points tested shall be within one half of the contour interval, unless otherwise stated on the survey. An American Standard Code for Information Interchange (ASCII) .txt file shall accompany all surveys and shall be in the following format:

Pt.# Northing Easting Elevation Descriptor (provide single spacing between fields)

3.7.2 Monuments

Monuments set by the surveyor shall be ferrous metal, at least 0.5 inches in diameter and at least 16 inches long. They shall bear a metal or plastic cap stamped with the surveyor's registration number. Sandia/NM Control Monuments shall be set in accordance with accepted standard drawings (see Attachment 3.B) for installation of brass caps. The surveyor shall submit a completed Monument of Record form for each monument established. The form can be obtained from Facilities System Engineering, Civil Engineering Department.

Corners which fall upon a hard surface shall be monumented with a chiseled cross or a nail in a disk or tag bearing the surveyor's registration number.

When a corner is located at a place where it is not practical to set a monument or a monument is likely to be destroyed, at least one reference monument shall be set and dimensioned on the plat such that the location can be reestablished.

The surveyor shall perpetuate monuments established by the Public Land Surveying System found in need of rehabilitation or replacement. A description of the monument as found and as restored or referenced and all available dimensions to other monuments shall be reported on a recorded plat. Said plat depicting only the rehabilitated or replaced monument will satisfy the requirements of this section.

3.7.3 Additional Information and Requirements

See Attachment 3.C for additional information. The attachment provides definitions of the general types of surveying and the minimum associated criteria as applicable at Sandia/NM. The types of surveying covered in the attachment are as follows: Boundary Surveying, Topographic Surveying, Easement Surveying, and Unclassified Surveying.

- End of Chapter -

Chapter 4 - Landscape Design Standards

4.1 Landscape Design

Provide landscaping according to the Sandia/NM Facility Campus Design/Development Guidelines. Landscape development should enhance the overall exterior appearance of buildings while emphasizing low water usage, minimal maintenance, and native plant materials.

Landscape irrigation and water conservation are long-term requirements at Sandia/NM and should provide a positive measure of efficiency in their actual performance as measured over time.

Consider landscaping when designing energy conservation solutions. Proper landscaping benefits include reducing solar radiation during cooling season, heat loss from wind, and heat loss during heating season.

Provide efficient and cost effective irrigation systems for turf and landscape areas that are reliable and compatible with Sandia/NM's Central Irrigation Control System. Each system shall be designed and installed such that its performance enhances distribution and emission uniformity and promotes the efficient use and protection of water resources at Sandia/NM.

Three Division 2 Construction Special Specifications have been posted on the engineering standards web site to assist in the landscape design effort.

- End of Chapter -

Chapter 5 - Structural Design Standards

5.1 Introduction

The following design standards are applicable to the structural work phase of the project. For general requirements associated with all phases of the project, see Chapter 2, General Design Standards and Procedures. For standard product specifications, see the applicable section in the Sandia/NM Facilities Standard Construction Specifications.

This Chapter applies to non-nuclear facilities with a Performance Category (PC) of PC-1 or PC-2 only. Facilities with a higher rating (PC-3, PC-4), nuclear facilities, and projects with special structural considerations are not covered in this Chapter, but shall follow project-specific Design Criteria.

5.2 Construction Drawings

5.2.1 Structural Drawings

Accurately prepare the drawings to scale with the various plans to the same orientation and scale. Refer to the Facilities CADD Standards Manual for scale and other CADD requirements.

Present details on separate detail system drawings sheets. Do not show details on plan or other types of system drawing sheets.

5.2.2 Drawings Required for Building Construction

The following provides a list of drawings required for the typical job. To illustrate the scope of a project, an approximate list of the plans and drawings required is provided in the design criteria for each discipline. You may suggest additional drawings to those listed. Arrange drawings in the order listed.

1. Structural Notes Sheet: provide any general notes, notes for specific materials or systems, design criteria and drawings.
2. Foundation Plan(s): All structural work for the foundation and footing construction. Use the highest elevation of the major ground floor slab as the reference place for drawing the foundation plan.
3. Foundation Section(s), Detail(s) and Schedules: All structural work for the foundation and footing sections and details. All sections and details must be labeled descriptively, and cross-referenced to the applicable Plan drawings.
4. Framing Plan(s): All structural framing (including cold form steel framing) by floor (including roof) and general structural notes.
5. Framing Plan Section(s), Detail(s) and Schedules: all structural work for the framing plan requiring sections and details, which must be labeled descriptively and cross-referenced to the applicable Plan drawings.
6. Miscellaneous: Elevations (Braced Frames, etc.)

5.3 Design Requirements

5.3.1 General

See Chapter 2, General Design Standards and Procedures, for information on the organization, arrangement of presentation, and computer applications. Place Structural Notes on the first structural sheet in the plans and list the following:

- Structural system description
- Codes and specifications
- Building Classification
- Building Performance Category per DOE-STD-1021-93
- Design loads and criteria
- Foundation notes
- Concrete notes
- Structural Steel notes
- Other pertinent structural information.

5.3.2 Design Loads

Design facilities by using the design loads set forth in the current edition of DOE Standard 1020- 2002. In this Standard, the design loads for PC-1 and PC-2 are the same as those published in the referenced edition of the International Building Code and the American Society of Civil Engineers' criteria for *Minimum Design Loads for Buildings and Other Structures*.

When designing spaces with Dowcraft™ or similar modular walls, limit the attached wall loads and accessories as follows:

- No more than four (4) shelves per panel.
- No more than twelve (12) shelves per wall overall panel run.
- Limit shelf weight to 40 lbs/linear foot (shelf full of text books and/or notebooks only).

5.3.3 Detailed Calculation Requirements

The required design calculations include but are not limited to the following types of information:

- Requirements, criteria sources, and references
- Loads, load factors, allowances for future loads
- Working or ultimate stresses and factors of safety
- Codes, manuals, special investigations, and reports used
- Complete calculations with loading, shear, moment, and stress analysis for all critical and typical members. An explanation for assumptions and conclusions is required
- Deflection calculations as applicable
- Applicable expansion, contraction, and crack-control measures
- Foundation characteristics
- Exploration requirements for foundations. Disclose soil and groundwater conditions for all major permanent structures. Investigate subsurface conditions by means of borings, test-pits, or other methods

- Alternative structural systems or materials considered

5.4 Conveying Systems

5.4.1 Bridge Cranes and Monorails

All crane and hoist designs, regardless of project size, are required to follow the Quality Assurance Review Process described in Chapter 2.14.1, Facilities Management and Operations Center Quality Assurance Review Process, and submit all documents for review to the Facilities Crane and Hoist Maintenance team. The design should address the following points (if applicable) in the specifications or on the drawings:

- Crane capacity
- Crane class
- Top running or underhung
- Bridge crane clearances
- Girder type
- Bridge speeds
- Bridge drive type
- Hook height
- Trolley speeds
- Hoist class
- Hoist lift
- Hoist speeds
- Push button pendant stations.

Other features that may need to be addressed include the following:

- Effects to any existing building structural system (foundations, columns, etc.)
- Remote control (radio)
- Special Pendant Travel System
- Pendant Retractor System
- Personnel catwalk along the bridge
- Ladder with platform to the catwalk.

- End of Chapter -

Chapter 6 - Architectural Design Standards

6.1 Introduction

The following design standards are generally applicable to the architectural phases on all projects. For general requirements associated with all phases of the project, see Chapter 2, General Design Standards and Procedures. For specific project requirements, see the Design Criteria.

6.2 Architectural Construction Drawings and Specifications

Architectural drawings for construction will include quantitative information. Qualitative information should be described in the accompanying project specifications and should not be duplicated on drawings.

6.2.1 Architectural Construction Drawings

See Chapter 2, General Design Standards and Procedures, for information on drawing organization and arrangement of the overall construction drawings set. Architectural drawings, and organization within the construction drawings set, include but are not limited to those shown in Table 6-1.

Table 6-1. Architectural Construction Drawings

Drawing	Scale	Remarks
Code Analysis and Life Safety Plans	To fit on sheet	If there is not enough room to provide the code analysis and life safety plans on one sheet, they may be separated.
Architectural Site Plan	Consistent with civil plans	Can be combined with civil and utility information provided architectural elements are clearly defined
Demolition and Removal Plans	1/8” = 1-0”	
Composite floor plans	To fit on sheet	Provide one plan per level in a scale that shows the entire layout on one sheet
Floor Plans		
Reflected Ceiling Plans		
Roof Plans		
Exterior Elevations		
Interior Elevations		Provide interior elevations when mounting heights and coordination of wall mounted items can not be clarified in schedules
Building Sections		
Wall Sections		
Enlarged Plans		Enlarged toilet plans and toilet accessory schedules should be shown on the same sheet
Stair and Elevator Plans		
Stair and Elevator Sections and Details		Sections can be ¼” = 1’-0”. Details will be 1-1/2” = 1’-0” or larger.
Exterior Details		
Interior Details		

Drawing	Scale	Remarks
Door and Window Drawings		Include schedules, elevations, and details
Equipment and Furniture Layout Plans	1/8" = 1'-0"	
Floor Finishes Plans		
Room Finish Schedule		Include Finish Material Legends
Signage Drawings		Include plans, elevations, sections, and large scale drawings as needed to coordinate signage
Signage Schedules		

Present all building plans at a scale of ¼ inch = 1 foot, unless noted otherwise on Table 6-1. See the Facilities CADD Standards Manual for additional information.

All plans shall be complete with labeled column or grid lines and north arrows. Include a scaled key plan, oriented in the same direction as the floor plan, on each partial plan sheet.

Present details on separate detail system drawings sheets. Do not show details on plan or other types of system drawing sheets.

6.3 Architectural Design Requirements

The following provides general guidance. For project-specific requirements, see the Design Criteria.

6.3.1 Site Development

6.3.1.1 Site Furniture

See the Sandia/New Mexico Facility Campus Design/Development Guidelines for additional information.

- Seating and tables
- Trash and cigarette receptacles
- Bike racks

6.3.1.2 Exterior Signage

See the Sandia/New Mexico Facility Campus Design/Development Guidelines for additional information.

6.3.1.3 Site Lighting

See Chapter 9.4.2, Exterior Lighting Systems Design, and the Sandia/New Mexico Facility Campus Design/Development Guidelines for additional information.

- Feature
- Building illumination
- Landscape

6.3.2 Building Substructure

6.3.2.1 Foundations

A dense concrete foundation with adequate control joints generally does not need to be waterproofed or damp-proofed in locations where the groundwater level is significantly below the foundation. Grade the site to provide drainage of surface water away from the building. Protect masonry walls below grade against leakage by using suitable cement parging and bituminous coatings or membrane applications.

6.3.2.2 Sub-drainage

In process.

6.3.2.3 Perimeter insulation

In process.

6.3.2.4 Basement Construction

Waterproofing

In process

Wall vapor retarders and insulation

In process.

6.3.3 Building Shell

6.3.3.1 Roof Construction

For single sheet metal roof decking, specify a minimum thickness of 22 gauge unless otherwise required by Factory Mutual (FM) or Class I roofs. Design the decking to limit deflection and protect the roofing from subsequent damage. Avoid using lightweight concrete over a metal deck.

6.3.3.2 Expansion control

Expansion joints in the roof assembly (including the roof deck) must be placed in the same location as the building's structural expansion joints. The joints must extend across the entire width of the roof and must never terminate short of the roof edge or perimeter. The joints must be designed to accommodate contraction as well as expansion. Expansion joints should always be provided at the following locations:

- Where expansion joints are provided in the structural system
- Where steel framing, structural steel, or decking change direction
- Where separate wings of L, U, T, or similar wings exist
- Where the type of decking changes (steel to concrete)
- Where additions are connected to existing buildings
- Where movement between vertical walls and the roof deck may occur.

Locate expansion joints at roof high points; water should drain in an opposite direction from each side of the joint. Elevate the expansion joint above the highest expected level of water flow as to not obstruct the flow of water off a roof.

6.3.3.3 Decks, slabs, and sheathing
In process.

6.3.3.4 Vapor retarders and insulation
As a general guide, vapor retarders should be considered when both the outside mean, average January temperature is below 40°F and the expected interior, winter, relative humidity is 45 percent or greater. The building usage must be considered in determining the need for a vapor retarder.

If vapor retarders are used, they should be constructed of materials that are compatible with the other roof system components. The designer should pay particular attention to flashing details at edge seals and at all penetrations through the vapor retarder in order to ensure its moisture-tight integrity.

Use only insulation approved for UL Class A and FM Class I roof construction on roofs. All roof insulation shall comply with the National Roofing Contractors Association (NRCA) Roofing and Waterproofing Manual and the NRCA Handbook of Accepted Roofing Knowledge.

Roof insulation should be installed in two layers when thickness permits, with all joints offset between the upper and lower layers. Mechanical fasteners should be used over steel decks to attach the first layer of insulation. For concrete decks, the first layer should typically be hot asphalt mopped to the concrete. The second layer should be fully adhered to the first layer and generally have the higher insulation value. The long dimension of the insulation boards should be laid perpendicular to the flow of water.

Performance type specifications should be avoided when specifying any insulation since manufacturers' data may vary considerably. The designer should list the appropriate ASTM specification, the thickness requirement, and the C or R-value for any insulation board to be used in the roof construction.

6.3.3.5 Roof Covering
Roof membranes shall be a single-ply type of PVC, Hypalon, or modified bitumen depending on the roof construction and type of building. A member of the Sandia/NM Roofing Committee shall provide guidance in deciding the type of membrane to be specified. In addition, Sandia/NM construction standard specifications for each type of roof membrane shall be provided and must be used in their entirety. Any modifications to the specifications shall be brought to the attention of the assigned Engineering Standard Program Committee member. UL Class A ratings are required for all roof membranes.

In process.

- Built-up
- Metal

6.3.3.6 Flashing
Membrane flashing materials must exhibit some degree of flexibility, be compatible with roofing membrane material, be resistant to traffic and natural damage, and be durable and weather

resistant. In general, they should be constructed with materials similar to those used in the construction of the roof membrane. Minimum heights of base flashings should be 8 inches.

Accessory metal should be used for covers, watersheds, or fascia, but typically should not be incorporated into the roofing membrane. Minimize direct contact of dissimilar metals to avoid electrolytic action.

Surface-mounted wall reglets are to be used in lieu of embedded types. Positive attachment using screws or bolts is required.

6.3.3.7 Drainage

Design and build all roofs to ensure positive, thorough drainage. The designer should not simply specify a standard 1/8-inch or ¼-inch slope per foot but shall make provisions for positive drainage. The structural framing, deck type, roof membrane, roof deflections, and building layout must all be considered in determining the necessary slope. Good roofing design dictates that there be no ponding water.

Locate drains at points of maximum deflection (i.e., mid-span) and not adjacent to columns, load-bearing walls, or any other structural member supported by the ground. If drains are required to be placed at columns or bearing walls, the slope of the roof must be increased to compensate for the minimum deflections at these locations. Roof drain spacing shall not exceed 75 feet in any direction. After drain locations are selected and deflections computed, the designer shall provide additional slope to ensure positive drainage. A minimum slope of 1/8 inch per foot should be added to the deflection computation. Structural decks that incorporate camber (precast concrete) must be considered in the design of the drainage slope system.

Drains should be recessed (sumped) below the roof surface with sufficient insulation placed around the drains to prevent condensation. Drainage crickets should be provided between drains and on the high side of mechanical curbs. Provide roof drains with a minimum 4-inch-diameter pipe size in lieu of gutters and downspouts. Provide a secondary drainage system (overflow scupper) on all roofs with parapets or curbs. The secondary system shall not be tied to the storm sewer and should drain to a highly visible area. The weight of retained water including that attributed to deflection of the roof due to the load of water below the bottom level of the overflow outlets shall be included in the structural calculations. Roof drains, gutters, and downspouts should be equipped with metal strainers to prevent obstructions by debris. Use seamless, one-piece gutters, downspouts, and splashblocks as much as possible.

6.3.3.8 Mechanical Curbs and Penetrations

Every roofing penetration is a potential source of water entry. Roof life can be maximized and roof maintenance lessened by minimizing the amount of rooftop equipment and penetrations. Wherever possible, place building equipment within a penthouse or inside the building. Where possible, combine utilities below the deck.

Where rooftop equipment installation in unavoidable, use supporting frames with round legs of sufficient height above the roof to allow easy maintenance and replacement without alterations. Follow the guidelines provided by the NRCA. Curbs are to be positively attached to the structural deck and located away from low spots in the roof.

Adequate space should be provided between mechanical units, penetrations, and walls so roofing materials can be installed correctly. Locate conduits, pipes, and other utilities at least 12 inches apart where they pass through the roof unless placed in a properly flashed curb opening. Base flashing should extend a minimum of 8 inches above the roofline. Coordinate all mechanical and electrical penetrations with the architectural roof drawings.

All penetration details require special attention. Every penetration should be addressed and appropriate flashing details specified rather than using typical details. Pitch pans or pockets are not acceptable. Use pipe boots or single-ply membrane flashings in general. Refer to the NRCA Roofing Manual and the SMACNA Architectural Sheet Metal Manual, or appropriate flashing details.

6.3.3.9 Protection and Maintenance

Provide wear-resistant roof walkways from points of roof access to penthouse entrances and to all roof-mounted and roof-accessible equipment that will require routine inspection and servicing. Movement of heavy equipment across a roof can cause permanent structural deflections and should be avoided. Specify a crane to place equipment where possible.

6.3.3.10 Reroofing

Design all reroofing projects following the principles stated above. In general, if the insulation is wet or is suspected to be wet, a complete tear-off down to the structural deck is required. Locate and note all rooftop equipment on the plan drawings. Disconnect all equipment, utilities, and curbs, and raise to the proper height. Remove abandoned equipment from the roof.

Each reroofing project will be unique in its own right. Discuss the design of the reroof in detail with the Sandia/NM project engineer prior to any design.

6.3.3.11 Openings

In process.

- Skylights
- Hatches

6.3.3.12 Fall protection

In process.

6.3.3.13 Canopies

In process.

6.3.3.14 Exterior Enclosure Walls

Use lightweight materials for floors, walls, partitions, and other building components where consistent with programmatic or operating requirements, economic objectives, fire protection and other safety requirements, and where there are no overriding acoustical requirements.

If the wall is to act as a filler or curtain wall, the connections to the structure must be capable of allowing the structure to deflect and yet maintain structural and weather-resisting integrity.

For exposed exterior walls, consider masonry composite walls, insulated metal, or concrete panels and other prefabricated wall construction. Avoid using brick because color matching is a problem. Do not use brick veneer supported by steel studs.

Where side-hill sites require use of concrete retaining walls, use these walls as building walls where practicable to achieve economy in construction.

Where the lower portion of exterior walls is subject to damage from vehicle traffic, material handling, or other activities, select a proper material and material thickness, or possibly provide a protective wainscot. Protect exposed insulation, light metal construction, or frangible materials from activities that could cause damage.

Building facades should reflect an honest representation of building function and the construction materials used. Consider, however, the relationship of new buildings to the surrounding site and existing buildings. Avoid clashes between existing and new architectural styles, but do not copy older, less suitable styles of architecture except possibly for additions to existing buildings.

Design story heights and bay sizes to accommodate coursing. Lay out masonry walls in even coursing to fit between beams, columns, and standard-size openings to minimize cutting of masonry units.

6.3.3.15 Exterior Finishes

In general, finishing of exterior walls should be kept to a minimum. Concrete walls should be left natural and unpainted unless economical finishing methods can be employed or where aesthetics and operating considerations require finishing. When using color treatment on exterior walls, select colors to harmonize with the environment and natural setting. Limit the number of colors used for a building or complex and carefully select them to provide a dignified public image.

Veneer
In process.

Non-structural concrete
In process.

Unit masonry
In process.

Exterior Insulation Finish System (EIFS)
In process.

Manufactured siding
In process.

Stucco
In process.

6.3.3.16 Expansion control

Provide adequate control and expansion joints when poured concrete floors or concrete or masonry walls are used. In long walls, carefully design and locate control joints to confine the effects of total expansion and contraction. In addition, provide necessary bond beams and anchors to structural framing for masonry units, and provide flashing, bond breaks, and weep holes to minimize the potential for moisture buildup and cracking due to differential movement.

Provide joints across buildings larger than 200 feet in length and where buildings have a significant change in plan dimension. Provide joints that can accommodate thermal-, moisture-, seismic-related movements. Structural expansion joints should extend from the roof to the foundation without offsets. Building expansion joints should not be less than 1 inch wide and should be designed to permit independent vertical and horizontal movements of the elements on either side of it.

Investigate manufacturers' research data and recommendations to realize optimum performance of the various materials.

6.3.3.17 Joint sealers

In process.

6.3.3.18 Special coatings

In process.

6.3.3.19 Painting

In process.

6.3.3.20 Waterproofing and Dampproofing

Protect masonry walls above grade against moisture penetration by means such as the following:

- Adequately filled, compressed joints
- Cement coatings
- Lintel and sill flashing
- Flashing or weatherbreak offsets at spandrels
- Overlapping weatherbreaks where masonry abuts columns and beams.

Caulk all doors, window frames, and other sources of leakage with a durable, flexible caulking compound. Design piping and other utility service penetrations to prevent leakage.

6.3.3.21 Vapor retarders and insulation

In general, the "U" factors for insulation should not exceed the values listed in the Mechanical Design Standards. Where composite walls are used, consider the compatibility of the insulating and facing materials. Vapor barriers and fibrous insulation shall be noncombustible or labeled by Underwriters Laboratories (UL) as meeting a flame spread rating of 25 or less and a smoke developed rating of 50 or less. For cavity walls, the use of treated (water repellent), granular fill may be appropriate. Rigid board insulation of cellular materials generally retains their insulating values longer than fibrous materials that are more vulnerable to moisture.

Foamed plastic insulation in exterior walls must be separated from the interior of the building by 5/8-inch, Type-X, fire-rated gypsum board, or an equivalent fire barrier.

Vapor barriers may be required in buildings with high wintertime humidity loads. Use the barriers in conjunction with insulation and locate them to avoid condensation in the insulation.

6.3.3.22 Parapets
In process.

6.3.3.23 Exterior louvers, grilles and screens
In process.

6.3.3.24 Building numbers
Provide building numbers on each major elevation as needed to be visible from approaching vehicles and pedestrians. Additional guidance for this section is in process.

6.3.3.25 Exterior Openings
Protect exterior walls and roof openings that are 1) less than 18 feet above ground level, 2) more than 96 square inches, and 3) more than 6 square inches in the smallest dimension. An exterior opening does not need to be protected if it is at least 18 feet above ground level and not readily accessible by ladders, has an adjacent roof surface, or has other means to assist access to the opening.

Exterior openings that require protection include doors, windows, ducts, crawlways, tunnels, and sewers. Protect these openings with steel bars or expanded metal grills. Approved protection includes a 1/2-inch-diameter bar on 6-inch centers and crossbars to prevent spreading, or expanded metal or grillwork. Approved security glass may be used in windows and doors in lieu of grills. Apply these security provisions to all construction unless otherwise specified. Provide self-closing rated assemblies or wire glass in rated steel frames wherever exterior openings are required to be fire protected per the IBC.

Windows
In process.

- Standard windows
- Storefronts
- Glazed curtain walls
- Security

Doors
In process.

- Entrance doors
- Utility doors
- Special
- Coiling
- Sectional

- Security

6.3.4 Interiors

6.3.4.1 Partitions

Provide fire separation walls (occupancy separation type and area separation type) as required by the IBC and the NFPA for separation of dissimilar occupancies or hazards, equipment rooms, stairwells, occupancy values, and as required to limit maximum floor areas.

Interior walls and partitions may be composed of materials similar to those used for exterior walls. Interior walls may also be prefabricated and either fire-resistant or noncombustible. Materials used for fire separation walls must have the required UL listed fire rating. On the floor plans, identify all walls (rated and nonrated) with a keyed note or a legend.

Specify that temporary interior construction barriers be covered with Type-X gypsum wallboard and painted to match existing wall surfaces when the barriers are intended to be in place for a significant amount of time and/or when the barriers are located in a highly visible area.

Observe the following limitations:

- Restrict the use of plaster to areas where the specific operation requires its use.
- Paint masonry walls where required by occupancy; otherwise, leave unfinished. Paint or seal masonry walls in equipment rooms and utility chases.
- Use 5/8-inch-thick type X gypsum wallboard throughout, with taped joints and Guidance for this section is in process. For project-specific requirements, see the Design Criteria or contact the SDR.
- Use cementations backer board at all wet service areas.
- To protect the more brittle or destructible wall finishes, provide noncombustible wainscot, and/or corner guards in areas subjected to excessive wear. Attach guards at 6 feet 0 inches off center maximum spacing.
- If acoustic materials are required on the walls, specify those that have a flame-spread rating of 25 or less and smoke-developed rating of 50 or less.
- Where tile finish is required by operations, limit the extent of application as practical. Where tile is used in toilet rooms, wainscot height shall be coordinated with the height of wall-mounted fixtures. Tile wainscot in showers shall be a minimum of 6 feet 0 inches from the finished floor.
- Take full advantage of modular bay arrangements for movable partition layouts. Sandia-furnished movable partitions are usually specified for areas of buildings where periodic rearrangement of space is likely. Movable parts are not normally used as fixed partitions around permanently assigned space except where the quantity of fixed partitions is small compared to the total number of partitions. When movable partitions are used, apply continuous floor and ceiling finishes before partitions are erected.
- Do not use foam plastic materials or foam-filled panels.
- Isolate the mechanical/equipment room from the remainder of the building with sound batts or double layers of gypsum board.

Additional guidance is in process.

- Fixed
- Demountable
- Operable

6.3.4.2 Windows

Design windows and doors to be of stock sizes and competitive design. Use the more economical industrial and energy-efficient types when practical. Select doors and windows to fit masonry coursing and the specified building module.

Keep glazing to the minimum necessary to satisfy basic functional and operating needs. When selecting fenestration methods and materials, carefully consider requirements that reduce building energy use in new facilities. All windows shall be double-pane insulating windows. For windows without security grills that are larger than 96 square inches and below 18 feet above ground level, use burglar-resistant glass as one of the two window panes and put all glazing stops on the inside of the building.

6.3.4.3 Doors

Aluminum and glass storefront doors (medium or wide stile) may be used for main entrances. Other exterior doors are usually flush, hollow metal, minimum 16 gauge in 14-gauge metal frames. Interior doors are usually flush, hollow metal, minimum 18 gauge in 16- or 14-gauge metal frames. Provide vision panels in doors in high-traffic areas and at all doors that swing into common hallways, corridors, or circulation areas. Specify properly labeled UL doors for all fire doors. Solid-core wood doors in hollow metal frames may be used in some administrative areas.

Use heavy-duty steel, roll-up, sectional, and other vertical doors in shops, warehouses, and industrial buildings for equipment and vehicular access. These doors should be weather-stripped in the best manner possible. Give special attention to the attachment and bracing of tracks and guides to ensure proper operation and to minimize maintenance. Bolt, rather than weld, all track attachments to the structure to allow for maintenance adjustment. Support doorframes rigidly to prevent cracking of adjacent finishes during normal use.

Additional guidance is in process.

- Entrance
- Standard
- Fire-rated doors

6.3.4.4 Hardware

Ensure that all builder’s hardware is utilitarian, economically competitive, and suitable for the required functions and that it meets handicapped accessibility requirements. Hardware shall be of durable grade and consistent with all appropriate Sandia/NM construction specifications and NFPA 101, Life Safety Code. Location of hardware shall also meet handicapped accessibility requirements. Avoid using concealed door closers when possible.

Provide an automatic door operator or other form of handicapped accessible assistance at main entrances to new buildings. Exterior door hinges shall be either nonremovable or fast-pin. Use

fire-rated hardware at all fire-rated door assemblies. Do not use fusible link arms on fire door closers except when permitted by the fire protection engineer. Where fire doors occasionally need to be held open, use electromagnetic hold-open devices actuated by the building fire alarm system. To be compatible with Sandia/NM's master keying system, all locksets (except push-button combination locks) shall use Sargent 5- or 6-pin cylinders. Keyway style shall be selected by the Sandia/NM locksmith and indicated on the hardware submittal.

6.3.4.5 Fittings

Visual display boards
In process.

Wall and corner guards
In process.

Identifying devices
In process.

Directories
In process.

Interior signage
In process.

Toilet accessories
In process.

Expansion joint cover assemblies
In process.

6.3.4.6 Interior Finishes

Provide finishes that are consistent with the character of the building. Paint or seal masonry walls in equipment rooms and utility chases. Consult with the Sandia/NM Architect when coordinating a color scheme for the interior colors.

Walls

- Standard
- Service areas
- Security
- Acoustical

Use qualified persons for acoustic design particularly in areas with high sound pressure levels and areas such as large conference rooms, data processing centers, word processing centers, auditoriums, audio/video studios, program control centers, and secure rooms.

In general, for industrial facilities or other high sound level facilities, the principal objectives are to achieve an acoustic environment that is noninjurious to the occupants and conducive to work performance and safety in operations. For nonindustrial-type facilities with lower sound levels,

the principal objective is to achieve a balanced acoustic environment for the occupants and the functions to be performed.

Do not provide acoustical treatment in storage areas or other service and support areas.

Give special consideration to utility rooms (mechanical/electrical equipment rooms) or other rooms where operating equipment is located. While such areas may not normally be occupied, high sound levels often exist that can be injurious to operating/maintenance personnel, even with short-duration exposure. Where acoustic treatment is not feasible or would not be adequate, anticipated noise levels and requirements for personal protective equipment (or the need for administrative control to limit employee exposure to safe duration periods) should be identified in advance of equipment operation. For reference, see 29 CFR 1910, Occupational Safety and Health Standards, Subpart G, 1910.95, Occupational Noise Exposure.

Floors

Generally, interior floor finishes shall be:

- Sealed concrete slabs in shops, equipment rooms, utility chases, warehouses, and other industrial areas
- Vinyl composition tile in laboratories and some office areas
- Carpet tile in office areas where specified
- Raised access flooring in computer rooms to accommodate cabling flexibility.

In process.

- Resilient
- Carpet
- Sealed concrete
- Vestibules

Ceilings

Keep ceiling heights in all buildings to the minimum consistent with operating requirements. Where the use of suspended ceilings is justified, keep floor-to-floor heights, and space above suspended ceilings to the minimum required to accommodate mechanical and other systems. Ceilings are generally 10 feet high in normal laboratory and administrative areas.

Interior ceiling finishes should comply with IBC and NFPA 101 requirements for Class A finishes, except in special instances.

In shops, warehouses, and other industrial-type buildings, leave the basic structure exposed without a ceiling finish except to isolate contaminated areas or where justified to facilitate heating, ventilation, sanitation, or reduction of excessive noise levels in specialized areas. Provide economically competitive, suspended ceiling systems with mineral fiber tiles in administrative and laboratory buildings.

In process.

- Exposed
- Gypsum board
- Acoustical

6.3.4.7 Vertical circulation

Stairs and Ramps

In process.

- Tread, riser, and landing finishes
- Resilient
- Carpet

Railings and balustrades

In process.

Painting

In process.

6.3.5 Conveying Systems

6.3.5.1 Elevators

Ensure elevators conform to the latest version of ASME/ANSI A17.1, "Safety Code for Elevators, Dumbwaiters, Escalators, and Wheelchair Lifts." All elevators with automatic doors and having a travel distance of more than 25 feet shall have firefighter service. Use a qualified elevator consultant to determine the number of passenger elevators, size and capacity, location, types of machinery, and controls; consider the building population, building layout, and traffic patterns. Locate freight or service elevators in proximity to loading docks, shipping and receiving areas, and storage areas. Combination service-passenger elevators for both the movement of equipment, furniture, and limited personnel use may be appropriate for buildings of less than three stories. All elevator controllers shall be non-proprietary. Elevator shafts shall be of fire-rated construction, rated in accordance with the IBC and NFPA construction of the building. For buildings taller than two floors, select at least one elevator whose cab size is compatible with a medical gurney and two emergency medical technicians with hand-carried equipment. The Architect will advise whether this requirement is needed on a given project.

6.3.5.2 Lifts

In process.

6.3.6 Equipment and Furniture

6.3.6.1 Equipment

Vending

In process.

Recycling

In process.

Mail Services and Computer Media Drop-offs

If the building is to be regularly occupied and have its own mail service, provide an administrative area near the building's entrance for Mail Services' mail-stop drop boxes, an outgoing mail drop, and a cabinet for disposal of excess computer media. These are free-standing furniture items, but are secured to wall or floor to prevent tip-over or removal. This area can be combined with another administrative service area such as a copy room, but should be close to the building's normal entrance. The area should not be in plain view of casual visitors to the building's entry.

Janitorial
In process.

Office
In process.

Customer
In process.

Furniture
In process.

Fixed casework
In process.

Window treatments
In process.

Fixed floor grilles and mats
In process.

Fixed multiple seating
In process.

Movable furniture and accessories
In process.

6.3.7 Special Construction

6.3.7.1 Pre-engineered structures
In process.

6.3.7.2 Selective demolition
In process.

6.3.8 Room Numbers

The A/E shall develop an initial room number scheme as part of Title I design. The room number scheme shall be finalized during Title II design. All spaces, including vestibules, alcoves, and secondary hallways or corridors shall receive a separate room number. The room number scheme shall be used for construction coordination and adopted to provide the final wayfinding and room numbering scheme for the facility. Separate room numbering schemes for construction and final

room identification for interior signage are not acceptable. The A/E shall meet with the Sandia/NM Project Team Architect to review the logic of the proposed room numbering scheme. Once accepted by the Project Team Architect, the room numbering scheme shall be used to coordinate final identification of building support and maintenance features such as panel schedules, communication drops, and mechanical piping, as well as room numbers on interior signage.

6.4 Architectural Calculation Requirements

Required design calculations include but are not limited to:

- Parking analysis. See the Sandia/NM Campus Design/Development Guidelines for additional information.
- Code analysis
- Fixture Count
- Perimeter envelope R and U values

6.5 Safety

Design all safety related building and site conditions to meet the requirements in Chapter 2.16, Safety Requirements, herein. Arrange all building and site egress components including but not limited to doors, stairs, corridors, partitions, gates and fences to facilitate direct and prompt evacuation through and away from the building in an emergency. All egress components shall conform to the applicable requirements of the IBC, NFPA 101 Life Safety Code, and the UFAS.

6.6 Flood Protection

In process. See Chapter 3, Civil Design Standards, for elevation requirements to protect facilities from flood.

6.7 Accessibility Requirements

Design all new and remodeled facilities to be safe and readily accessible to, and usable by individuals with disabilities. Elements that require consideration include parking [refer to Section III.a of the Campus Design and Development Guidelines for quantity requirements], access routes or path of travel, signage, entrances and vestibules, ramps, stairs, doors, rest rooms, assembly spaces, water fountains, telephones and elevators. The Uniform Federal Accessibility Standards, Federal Standard 795, and the Americans with Disabilities Act, Accessibility Guidelines for Buildings and Facilities, have published guidance for design of these facilities. The building design shall also allow for safe egress of individuals with disabilities in an emergency. Provide Areas of Rescue Assistance as required by code or as designated by Sandia/NM

6.8 Telecommunications Intermediate Distribution Rooms (IDRs)

Refer to Chapter 10, Telecommunications Design Standards, for architectural requirements for IDRs.

- End of Chapter -

Chapter 7 - Fire Protection Design Standards

7.1 Introduction

The objective of Sandia/NM's fire protection program is to provide comprehensive fire and related hazards protection for facilities sufficient to minimize the potential for:

- The occurrence of a fire or related event.
- A fire that causes an unacceptable on-site or off-site release of hazardous or radiological material that will threaten the health and safety of employees, the public, or the environment.
- Vital Sandia/NM programs suffering unacceptable interruptions as a result of fire or related hazards.
- Property losses from a fire and related events exceeding defined limits established by DOE.
- Critical process controls and safety systems being damaged as a result of a fire and related events.

Sandia/NM facilities, sites, and activities shall be equipped with level of fire protection that is sufficient to fulfill the requirements of a best-protected class of industrial risks ("Highly Protected Risk" or "Improved Risk"), and shall be provided protection to achieve "defense-in-depth." When significant modifications to a facility occur, the current version of the code or standard shall apply to the modification.

Sandia/NM Fire Protection Engineering shall be consulted during the scoping phase of a project to determine the level of protection necessary for the facilities, and the type of system to be utilized. Facilities Mechanical and Civil Engineering Department shall be consulted for exterior water utility connections and available fire flow capacities. The design documents and construction submittals shall be reviewed by the Sandia/NM Fire Protection Engineer and the design engineer for compliance with Sandia/NM requirements.

For design requirements for the building fire protection piping distribution system downstream of the flanged stub-up above the building slab, refer to Facilities Construction Standard Specification Section 15310, Automatic Sprinklers and Water Based Fire Protection Systems. Refer to Chapter 3.4.1 for design of underground fire protection water lines.

Fire hazard analyses (FHA) shall be prepared for significant new facilities, and facilities that represent unique or significant fire safety risk. The FHA shall be developed using a graded approach, and the conclusions of the FHA shall be incorporated in the Safety Analysis Report (SAR) and integrated into the design basis. Sandia/NM Fire Protection Engineering will provide guidance and support in the preparation of the FHA.

7.2 Automatic Sprinklers

Wet-Pipe automatic sprinklers are the preferred fire protection system and are required installation in the following locations:

- All structures (including temporary or relocatable) over 5,000 square feet in size.
- In all structures having a Maximum Probable Fire Loss (MPFL) in excess of $1,000,000.
- In all structures where the MPFL will affect a vital program longer than that specified as acceptable by the Sandia/NM Corporate Fire Protection Program document.
- In all structures where hazardous materials are used or stored in excess of the limits delineated in the International Fire Code, or National Fire Protection Association Standards.

Automatic fire sprinklers shall be provided throughout the building. Sprinkler system occupancy classification design density and system type shall be determined with guidance from the Fire Protection Engineering and Facilities Construction Standard Specification Section 15310.

The system shall be wet-pipe, unless otherwise specified. Design the system in accordance with Facilities Construction Standard Specification 15310, Automatic Sprinklers and Water Based Fire Protection Systems. The sprinkler system may be designed and installed by a licensed sprinkler contractor, or designed by an A/E firm with fire protection expertise and installed by a licensed contractor. The designer of the fire protection systems shall meet one of the requirements below.

A. A Registered, Professional Fire Protection Engineer in the State of New Mexico.
B. Minimum National Institute for Certification in Engineering Technologies (NICET) Level III for wet-pipe or dry-pipe, Ordinary Hazard, Group II Sprinkler Systems, regardless of size.
C. Minimum National Institute for Certification in Engineering Technologies (NICET) Level IV for all other types of systems, including special hazard protection.

For new building design, the sprinkler piping system shall be a separate service entrance, and the riser shall contain an outside stem and yoke gate valve, an alarm check valve, plus a reduced-pressure backflow prevention (RPBFP). See Chapter 7.3, Fire Protection Backflow Preventers, for design requirements. Fire riser system and catastrophic drains to the exterior of the building shall be located such that the discharge does not normally flow onto sidewalks, parking areas, and similar areas. The intent is to prevent additional hazards from sudden discharges where people might gather, and to reduce accumulation of ice on walkways and roadways in freezing weather.

Provide a fire department connection for the building in an area accessible for the first response unit from Kirtland Air Force Base (KAFB) Fire Department. The fire department connection shall be located in close proximity to the main entrance or location of the Fire Alarm Panel. This will allow the first responding fire department apparatus to pull up to the front of the building, check the panel and connect to the Fire Department Connection if necessary.

The fire protection designer shall indicate the entire area to be sprinklered, and those areas that do not require sprinklers (concealed spaces exempted by NFPA 13). The fire protection designer shall also indicate the following:

- Areas to be sprinklered
- Occupancy classification (Refer to Table 1.04B, Construction Standard Specification Section 15310, Automatic Sprinkler and Water Based Fire Protection Systems)
- Sprinkler type
- Design density
- RPBFP (including drainage and control valves)
- Water supply main size, location
- Water supply data
- Fire hydrant location and number
- Lead-in size location and number
- Post indicator valve(s) location and number
- Riser location
- Fire department connection location
- Fire department access
- Vehicular barriers
- Standpipes

Place the words “Fire Protection” in the title block of the drawing. Develop the drawings in accordance with Facilities Construction Standard Specification 15310, Automatic Sprinklers and Water Based Fire Protection Systems.

Provide heating for sprinkler-protected spaces in lieu of providing anti-freeze systems. In unheated areas such as vehicular airlocks, airlocks, canopied areas, etc., a dry-pipe valve system should be specified.

For modular designs, arrange sprinklers in a repetitive pattern where possible. The sprinkler placing shall be approved by the Sandia/NM Fire Protection Engineer before Title II drawings are submitted.

Seismic protection for automatic sprinkler systems is required for all new systems. Consult with the Sandia/NM Fire Protection Engineer regarding modifications to existing systems. The installation guidelines for seismic protection in NFPA 13 shall be used. Where an alternative method (other than NFPA 13) of providing seismic protection of a sprinkler system is to be used, only UL Listed or FM Approved material shall be permitted. The alternative method shall have a design based on a dynamic seismic analysis certified by a Registered, Professional Engineer (PE) in the State of New Mexico and shall be stamped by the registered PE.

Where future expansion is to be considered, sprinkler protection shall also be considered. Include a key plan to scale on the drawing to clearly show this situation. The piping size for planned expansions and additions will be established with the design of the sprinkler system for the immediate project. This guidance shall be provided in the project-specific Design Criteria.

Class I standpipes shall be installed in all structures having three levels or more above or below grade.

7.3 Fire Protection Backflow Preventers

Automatic fire sprinkler systems that are provided with a cross-connection to the site potable water supply require installation of a backflow prevention device to protect the water supply from possible pollution and/or contamination hazards present within the fire sprinkler system.

Backflow prevention devices should be installed inside the facility. The fire sprinkler riser and backflow prevention device shall be located such that sufficient space is provided for testing and maintenance purposes (approximately 60 feet square). The fire sprinkler riser may be located in a dedicated riser room or in other suitable spaces (i.e., mechanical equipment rooms or under stairs) to reduce cost.

The A/E shall select the proper type of backflow prevention device based on the International Plumbing Code (IPC) and the guidance in this document. The most common type of sprinkler system at Sandia/NM is a wet-pipe sprinkler system with no fire fighting additives. This system would normally require the installation of a double check valve backflow prevention device. To assist in this selection, Table 7-1 identifies the types of backflow prevention devices allowed for fire sprinkler systems and indicates what level of hazard to the water supply and the type of backflow that device can protect against.

Standard Drawing Numbers FX5003STD, Alarm Valve, Air Gap Interior Details, and FX5004STD, Alarm Valve Piping, should be used, with the proper detail selected by the A/E for application. Reduced pressure backflow prevention devices installed inside of a facility require the installation of the Air Gap Drain Assembly to allow for diversion of catastrophic drain from backflow device in the event of its failure. Double check valve devices installed inside and outside of facilities, and reduced pressure devices installed outside of a facility do not require the air gap assemblies.

Table 7-1. Fire Protection Backflow Prevention Device Application Table

DEVICE	HAZARD		APPLICATION	
	Low[1.]	High[2.]	BACKSIPHONAGE[3.]	BACKPRESSURE[4.]
Reduced pressure principle backflow preventer.	**YES**	**YES**	**YES**	**YES**
Double check backflow prevention assembly.	**YES**	**NO**	**YES**	**YES**

Definitions

1. **Low Hazard** – Pollution in the potable water supply exists when the quality of water is impaired to a degree such that the aesthetic quality of the water is adversely affected. However, in such a condition, there is no hazard to the health of the public. Ordinary wet-pipe, dry-pipe, pre-action, and deluge automatic fire sprinkler systems – with no fire fighting additives – would normally be placed in this category.

2. **High Hazard** – Contamination in the potable water supply exists when the quality of water is impaired to such a degree that an actual hazard to the public health through poisoning or through the spread of disease. Examples of in fire protection would include “foam-water” sprinkler systems such as Aqueous Film Forming Foam (AFFF), “anti-freeze” or “non-freeze” systems containing glycerin or glycol.

[3] **Backsiphonage** - The backflow of potentially contaminated water into the potable water system as a result of the pressure in the potable water system falling below atmospheric pressure of the plumbing fixtures, pools, tanks or vats connected to the potable water distribution piping.

[4] **Backpressure** - Pressure created by any means in the water distribution system, which by being in excess of the pressure in the water supply mains causes a potential backflow condition.

In some cases, sub-systems of automatic sprinkler systems may considered to be in the High Hazard category, while the remaining portion of the sprinkler system would fall into the Low Hazard category. For example, these sub-systems may be attached to part of a wet-pipe sprinkler system, and most commonly are the 'anti-freeze' and foam-water sprinkler systems. The A/E should select a reduced-pressure backflow prevention device and place at the service entrance for the entire sprinkler system, in lieu of providing one type of backflow prevention device for the sub-system and another at the service entrance.

7.4 Fire Alarm System Design

7.4.1 System Description

Fire alarm signals are sent to one of the two proprietary supervising stations at Sandia where alarms from building fire alarm control panels are collected and distributed to emergency responders. The first system is a Honeywell Delta 1000 system located in Building 829. The Honeywell station is being phased out of operation. The Honeywell Delta 1000 software will only communicate with Honeywell Model FS20 and FS90 Data Gathering Panels (DGPs) fire alarm control panels. The FS20 and FS90 DGPs communicate with the Honeywell Delta 1000 station using dedicated phone lines that bypass the telephone switch.

The new proprietary supervising station is located in the Building 887 IDR. This station utilizes a Digital Alarm Communicator Receiver (DACR) to receive alarms from Digital Alarm Communicator Transmitters (DACTs) located in fire alarm control panels. The DACTs communicate to the station DACR over primary/secondary dual telephone lines using Ademco Contact ID communication format. Only the fire alarm control panels specified in Construction Standard Specification Section 13852, "Intelligent Fire Alarm System," shall be installed in Sandia facilities.

7.4.2 References

The current edition of the following Construction Standard Specifications shall be utilized for the design and installation of fire alarm systems.

- Section 13851, Honeywell Fire Alarm System (use only for modifying existing Honeywell fire alarm systems)
- Section 13852, Intelligent Fire Alarm System
- Section 13854, Prefabricated Office Units Fire Alarm System

The latest revision of the following Standard Drawings shall be utilized for the fire alarm design requirements.

- E-0006STD – Standard Symbols List and General Notes
- FA5002STD – Conventional Initiation Device Details (use only for existing Honeywell fire alarm systems)
- FA5003STD – Installation Details
- FA6001STD – Honeywell Fire Alarm Equipment Schedule (use only for modifying existing Honeywell fire alarm systems)
- FA7001STD – Fire Alarm Wiring Diagrams
- FA7002STD – Notification Appliance Wiring Diagrams

7.4.3 Design Criteria for New Installations

All new fire alarm system installations shall be an addressable intelligent fire alarm system, a design/build installation performed by a qualified fire alarm installer per the requirements in Construction Standard Specification Section 13852, "Intelligent Fire Alarm System".

7.4.4 Design Criteria for Modifying Existing Installations

Modifications to an existing conventional (e.g., Honeywell) fire alarm system shall be designed by the A/E per the design criteria in Construction Standard Specifications, Section 13851, "Honeywell Fire Alarm System" and Section 13852 "Intelligent Fire Alarm System", Part 1.07 "Design Criteria".

When initiation devices are added to a conventional fire alarm system, the devices shall be divided into zones that allow emergency responders to quickly identify the location and device(s) in alarm. Devices that are located on different floors or in separate wings of a building shall not be placed on the same zone. Manual pull stations and heat detectors can share the same zone. Group smoke detectors on the same zone. Multiple duct smoke detectors can be installed on the same zone if they are installed on the same air-handling unit and in the same general area. Each water flow detection device shall have its own zone. Combine valve supervisory switches, including PIV tamper switch, that is in the same general area for the same sprinkler riser on the same zone. Each control panel for miscellaneous systems shall be provided with a dedicated zone.

Modifications to the Signal Line Circuit (SLC) of an intelligent fire alarm system shall be a design/build installation performed by a qualified fire alarm installer for the fire alarm system in service. The requirements of Construction Standard Specification Section 13852, "Intelligent Fire Alarm System" apply to the design of the system modification.

Minor modifications to existing Notification Appliance Circuits (NAC), such as adding or relocating appliances, shall be designed by the A/E per the applicable Construction Standard Specifications, Section 13851 for Honeywell fire alarm systems and Section 13852 for intelligent fire alarm systems; and the requirements in Section 7.4.5 "Notification Appliances" of this Design Manual

7.4.5 Notification Appliances

Provide multi-tone horn and strobe notification appliances throughout the building to comply with NFPA 72 requirements.

Wiring: Notification Appliance Circuits (NAC) shall be wired as NFPA 72 Class B, Style Y. NAC cables shall be terminated only at panels or appliances; splices are not permitted.

Multi-tone Horns: The tone for electronic audible appliances is standardized as a bell setting (1560 Hz modulated @ 0.07 seconds On/Repeat) for the Sandia –NM site. Locate multi-tone horns on floor plans to provide a minimum of 15 decibels (dBA) above the ambient background noise. In addition to hallways and common areas, provide multi-tone horns inside labs and in the occupant work locations to more effectively notify building occupants. Assume that the output of the multi-tone horn is reduced by 6 dBA as the distance between the appliance and the listener is doubled. Take into consideration the acoustic properties of the materials in the listening space, such as the wall and door construction, when locating audible appliances on floor plans. Where ambient noise levels exceed 105 dBA, provide a strobe in addition to the multi-tone horn. Utilize the values in Table 7-2 for the ambient background noise levels for the different occupancies when locating audible appliances.

Table 7-2. Ambient Background Noise Levels for Different Occupancies

Location	Average Ambient Sound Level (dBA)	Minimum Sound Level (dBA) Required
Office Areas	55	70
Assembly Areas	55	70
Storage Areas	55	70
Computer Rooms	70	85
Labs	70	85
Low and High Bays	70	85
Clean Rooms	70	85
Mechanical Equipment Rooms	90	105

Strobes: Provide visual notification appliances in all common areas (e.g., restrooms, conference rooms, break areas, corridors, hallways, stairways, lobbies), open areas with calculated occupant loads of 10 or more occupants, and in locations with a high ambient sound level (e.g., mechanical equipment rooms). Locate strobes per the requirements in NFPA 72.

Emergency Responder Multi-tone Horn/Strobe: At the main entrance(s) to the building, provide a weatherproof multi-tone horn/strobe appliance on the exterior wall of the building that is readily visible to emergency responders and Security patrols for signaling when the building fire alarm system is in an ALARM condition.

NAC Power Supplies: Provide NAC power supplies through out the building to provide power for the audible/visual appliances and to reduce voltage drop on notification appliance circuits. Provide a dedicated 120 VAC, 20-amp branch circuit from the nearest power panel to power the NAC power supply. Locate the NAC power supplies in accessible locations for maintaining the panels (e.g., equipment chases, utility rooms).

Zoning: The boundaries of notification appliance circuit zones shall be coincide with building outer walls, building fire or smoke compartment boundaries, floor separations, or other fire safety subdivision. NAC zones may contain any combination of multi-tone horns and strobes. Initially load each NAC zone with appliances that do not exceed 80 percent of the available NAC amperage to permit later addition of notification appliances to the circuit. For NAC appliances powered from the FACP, indicate on the floor plans the NAC output or zone number for each appliance (e.g., NAC1, Z-2). For NAC appliances powered from NAC power supplies, indicate on floor plans the power supply identifier and output number (e.g., PS1-4, PS2-1).

7.4.6 Drawing Requirements – Intelligent Fire Alarm System

For new intelligent fire alarm system designs, provide plans indicating the location of the following equipment:

1. Fire Alarm Control Panel
2. Fire suppression release panels
3. Air-sampling control system panels
4. HVAC control equipment/panels requiring interface with fire alarm system for equipment shutdown.
5. Smoke removal control panels requiring interface with fire alarm system for equipment activation.
6. Fire/smoke dampers requiring interface with fire alarm system.
7. ADA phones requiring interface with fire alarm system.
8. Fire doors requiring interface with fire alarm system to release (close) doors during an alarm event.
9. User equipment requiring interface with the fire alarm system.
10. Location of the automatic sprinkler system Post Indicator Valve.

The fire alarm installer will use these drawings to generate shop drawings for the design of a complete fire alarm design/build package.

The A/E shall provide panel schedules indicating the 120 VAC branch circuit supplying power to the FACP.

7.4.7 Drawing Requirements – Conventional Fire Alarm System

For modification to a conventional fire alarm system, provide plans indicating the location of the following equipment:

1. Fire Alarm Control Panel
2. Annunciators
3. Initiation devices
4. Notification appliances

5. NAC power supplies
6. Fire safety function equipment requiring connection to fire alarm system (e.g., magnetic door holders, HVAC fan shutdown equipment, fire/smoke dampers, elevator recall/shutdown).
7. Ancillary panels (e.g., air sampling control panels, fire suppression release panels).
8. Post Indicator Valves and other equipment located outside building connected to fire alarm system.

Revise the existing floor plans and building riser elementary wiring diagrams as required to reflect the modifications being made to the conventional fire alarm system Initiation Device Circuits and Notification Appliance Circuits.

Provide panel schedules indicating the 120 VAC branch circuit supplying power to the FACP and NAC power supplies.

Utilize the guidance and requirements in the Facilities CADD Standards Manual and as specified elsewhere in this Design Manual for the preparation of the following drawings to delineate the fire alarm system design.

7.4.8 Calculations

Provide amperage load and voltage drop calculations for each Notification Appliance Circuit. The amperage load for each NAC shall not exceed 80 percent or the rated load to permit later notification appliance additions to the circuit.

7.4.9 Fire Alarm Systems in Temporary Structures

New fire alarm system installations in temporary structures (e.g., mobile offices, T-buildings) with occupants shall utilize an addressable intelligent fire alarm control panel designed and installed per the requirements in this section of the Design Manual and the Construction Standard Specification Section 13854, Prefabricated Office Units Fire Alarm System. For occupied temporary structures that are not physically connected to other similar structures and have an occupant load of less than ten people, provide commercial-grade 120 VAC photoelectric smoke detectors with an audible base, spaced throughout the structure according to the manufacturers recommendations, to notify occupants to evacuate the structure. If the temporary structure(s) are located in close proximity to a permanent building containing a fire alarm system, consider connecting the fire alarm system in the structure(s) to the building fire alarm control panel if it will be cost effective to do so.

7.4.10 Coordination with Sandia

Contact the designated Sandia Fire Protection Engineer when 1) additional notification appliances will be added to an existing NAC to confirm that the circuit will not be overloaded and 2) if a new IDC zone will be added to the Honeywell DGP for verification of the DGPs capacity to handle the additional circuit(s).

- End of Chapter -

Chapter 8 - Mechanical Design Standards

8.1 Introduction

The primary objective of these guidelines is to achieve consistency and accuracy in mechanical facilities engineering design through awareness and standardization. These guidelines are general in nature and shall be supplemented by the applicable codes, standards, and guides referenced in this manual. Specific conditions outlined in the project-specific Design Criteria take precedence over these design guidelines.

For general requirements associated with all phases of the project, see Chapter 2, General Design Standards and Procedures. For individual project requirements see the Design Criteria.

For standard product specifications, refer to the applicable section in the Facilities Construction Standard Specifications. Where manufacturers are specifically called out, the purpose is to indicate the desired features and associated level of quality.

As a minimum, all new construction shall conform to the International Code Council (ICC) group of codes. These building code requirements shall be supplemented in a graded manner with additional safety requirements associated with the identified facility hazards. Base design decisions on the lowest life cycle cost of the system.

8.2 Construction Drawings

8.2.1 Drawings Required

To illustrate the scope of a project, an approximate list of the plans and/or drawings required is presented in the Design Criteria for each discipline. Additional drawings may be suggested. Check the Facilities Standard Drawings for applicability to project. Refer to the Facilities CADD Standards Manual for specific CADD standards and processes. The following is a list of plans and/or drawings required for a typical job. (Note: Sandia/NM follows the Uniform Drawing System (UDS) for numbering drawings.) The UDS discipline designators are listed for common systems:

1. Exterior Utilities: Includes but is not necessarily limited to new and existing yard plans showing district steam, condensate return, exterior chilled water, natural gas, fuel oil, special waste disposal system, etc. Other utilities are listed in Chapter 3.2, Construction Drawings. The UDS discipline designators are ‘WG’-Natural Gas, ‘WM’-Steam & Condensate, ‘WH’-Chilled Water.
2. Plan and Profile: Drawings of new site utilities.
3. Interior Plumbing Layout: Show domestic hot and cold water, non-potable water, sewer, vents, drains, lab waste and vents, pressure drains, rainwater leader, and storm drains. Use an isometric diagram to show the sewer, vents, drains, and pressure drains. Use a separate isometric diagram to show the domestic hot and cold water.

4. Interior Gas and Process Gas Plan(s): Show compressed air, nitrogen, natural gas, vacuum, process gases, gas bottle racks, etc. Use a separate Piping Schematic drawing to show all gasses. The UDS discipline designator is 'DJ'.
5. HVAC Piping Plan(s): Show heating water, pressurized steam and condensate return, tower water, fuel oil, chilled water, condensate drains, or other type of distribution system. In areas where the HVAC piping becomes involved, or where piping is overlaid on the plan, use above-ceiling and below-ceiling plan(s), and use additional sections, details, or piping schematics for clarification. The UDS discipline designator is 'MP'
6. Process Liquids Plan(s): Show de-ionized water, process chilled water, hydrochloric acid, process oil systems. In areas where piping becomes involved, or where piping is overlaid on the plan, use additional sections, details, or piping schematics for clarification. The UDS discipline designator is 'DP'
7. HVAC and Exhaust Duct Plan(s): Show all air distribution, exhaust handling equipment, ductwork, hoods, diffusers, fittings drawn to scale and thoroughly dimensioned. Provide isometric and/or sectional details where the layout becomes complex. Provide separate HVAC and Exhaust Duct plans for extensive exhaust systems. The UDS discipline designators are 'MP'-HVAC' and 'MJ'-Exhaust.
8. Separate Roof Plan: Show all roof-mounted equipment, vents, special exhausts, catwalks, etc.
9. Flow Diagram: Schematically shows all heat-transfer processes involved. Show exhaust systems; indicate each source of exhaust, room number, design flow rates, riser flow rates, fan flow rates, dampers, and all other components.
10. Riser Diagram: Show all piping and air handling systems in buildings other than single-story buildings. Key each riser to the appropriate plan.
11. Detail Drawings: Drawings for the above items, showing sections and details. Do not present details and sections on the plan sheets.
12. Control Drawings: Create Control Plans Drawings, Diagrams, Sequence of Operations, Panel Details, Equipment List, and Ladder Diagrams. Group the entire set of controls drawings together in a separate discipline with the UDS designator 'MI'. On plan drawings, show the location of each item of control equipment, a scale of 1/8 inch per foot or smaller is suggested for most areas of buildings to allow better coordination of the various items in the system drawings. Scales of ½ or ¾ inch per foot may be required in congested equipment rooms. Provide schematic diagrams referring to all control functions and actions. The control diagram shall show control components on a flow diagram with the control piping or wiring in heavy gauge lines. In addition, show the associated heat transfer items such as fans, ductwork, dampers, pumps, coils, pipes, and valves, in light gauge lines such that the total system operation can be determined from the diagram. Provide Sequence of Operations that fully describes the operation of all controlled systems in all modes of operation. (See Chapter 8.23, Controls, for further guidance on controls definition.) Create a layout schedule of panel control devices using an Excel spreadsheet as a format. (See FCS Standard drawing MI5001STD for further guidance.) Because the Facilities Control System (FCS) is unique, the required drawings are listed with the system description. Criteria listed above, applicable to the FCS components, will hold. For reference, utilize FCS Standard drawings; MI5001STD, MI6001STD, MI6002STD. See Chapter 8.23.1, Facilities Control Systems, for additional information for FCS.

13. Equipment Symbols, and Schedules: Group these together on a special drawing(s) rather than scattering them throughout the set. Start the equipment schedules in the upper left hand corner of the drawing. Use Sandia/NM standard format and symbols. Do not duplicate numbers.

8.2.2 Piping Drawings

Generally, one-line drawings are satisfactory for designating piping. In certain instances where piping is complex and crowded with other piping or equipment, to-scale, two-line drawings are required to ascertain that all items will fit without interference (for example, the rising screw on an outside screw and yoke must have adequate clearance when the valve is open). Provide pipe elevations and/or sections for pipes that cross in the plan view.

8.2.3 Schedules

Where the same information is repeated several times, provide a complete, well-arranged schedule (for example, traps and coils could be put in one schedule, complete with capacities, pressure drops, temperatures, etc.). Group schedules together on a drawing(s) adjacent to the equipment list sheet(s) rather than scattering them throughout the set of drawings. Use a standard, sequentially numbered symbol for each item. When scheduled items share a common description, a letter can be appended to the symbol number (e.g. 15a, 15b, 15c, etc.)

8.3 Access and Layout

8.3.1 General Requirements

In general, provide approximately 8 percent of the gross area of the building to house mechanical equipment (fans, compressors, chillers, pumps, electric motor control center, etc.). This area will allow for installation and maintenance of equipment. The following guidelines should be followed for the mechanical equipment room:

- The aspect ratio of the room should not exceed 3 to 1
- Indicate tube pulling space for boilers, chillers, and heat exchangers
- Verify that equipment can be installed during construction
- Provide access to remove equipment that has a relatively high rate of failure
- Where feasible, do not install piping or ductwork below 7 feet above the finished floor where passage is required.
- Indicate coil removal and filter access space for air handler units.

Locate items needing periodic repair, adjustment, or lubrication where they can be accessed from a standing position. Lay out equipment rooms to allow for 36 inches of clear floor and aisle space around all major equipment. Arrange or provide space so tube bundles can be withdrawn or major items of equipment can be replaced without repiping or relocating other equipment. Where necessary, provide areaways and/or removable wall panels for access. Anticipate and eliminate head-bumping or tripping hazards. On the structural drawings, accurately detail and locate sleeves through walls and floors. Field welding or cutting structural steel is forbidden. Lay out manholes so personnel can exit quickly. Where possible, locate a manhole cover over the ladder.

Size and ventilate workspaces to provide adequate working conditions for maintenance personnel. Clearly state mounting heights for wall-hung items, or provide elevations of crowded walls, particularly where electrical and structural items are also involved. Arrange pipes in pipe space/chases to allow a mechanic to conveniently get into the pipe space and work on a section or part of the piping.

Inform the architectural and structural designers of all ladders, catwalks, access doors, and special structural equipment needed for the proper maintenance of mechanical equipment.

The space above suspended ceilings shall be adequate to run ductwork and piping. Normally allow a 3-foot-minimum clearance from the top of light fixtures to the bottom of construction for the installation of ductwork and piping.

Provide a minimum 6-foot-edge clearance for roof-mounted equipment unless pipe guardrails are provided.

Provide access doors to gypsum board ceilings and other restricted spaces where mechanical equipment is located.

8.3.2 Security Requirements

For building that straddle the boundary of security area, protect openings along the boundary greater than 96 square inches and any area within this opening that is greater than 36 square inches, using bars, expanded metal, grillwork, or an alarm system. Examples are heating, ventilating, and air conditioning ducts; air intakes, exhaust fans or ducts; and doors, crawlways, tunneled areaways, and sewers. Where the mechanical designer is responsible for the design and placement of such items, communicate the information to other responsible consultants who will take the necessary electrical or structural steps to ensure compliance with security requirements. Ensure that these steps have not introduced excessive resistance or other problems into the original design. Recalculate and modify as required.

Similar requirements may apply to vault type rooms, SCIF facilities, or other buildings with unique security requirements as mentioned in the Design Criteria. See Chapter 11.6 for requirements for vault-type rooms.

8.4 Modular Design

Design mechanical systems in the most flexible manner possible, since changing programs and occupants result in changing needs. Do not oversize systems dramatically. Arrange diffusers, registers, sprinkler heads, and other semi-permanent features on the module system for future flexibility of walls and partitions. Contact the Sandia/NM systems architect for additional information on the module system.

8.5 Equipment Selection–General

Because the selection of mechanical equipment is involved, provide copies of calculations and standard or actual conditions used for the selection of all mechanical equipment, even when

following the manufacturer's procedures. Make adjustments to manufacturer's altitude rating as required for the Sandia/New Mexico altitude of 5,500 feet. Comply with ASHRAE Std. 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings, for minimum equipment efficiencies.

A brief but complete description of equipment shall appear on the equipment list drawings. The designer shall locate and describe one manufacturer's model that meets design requirements. Present the manufacturer's complete catalog number and all rating and performance information. Generalities in selection are unacceptable. Provide additional special specifications to equipment schedules to more fully describe complicated equipment. Use performance specifications that will ensure a quality product. Key mechanical item numbers to the plans and elevation drawings.

A partial load schedule, in 10-percent steps, will be established, and the manufacturer's actual performance data shall be listed for all variable-capacity, heat-transfer equipment.

All equipment assemblies requiring line electrical power shall have a local power disconnecting means rated for the service. Refer to paragraph 9.3.5 for requirements.

Whenever mechanical equipment is specified as a complete unit with electrical components such as motors, VFDs, disconnects, lighting and wiring, the associated electrical specifications shall be referenced to insure that these components meet those specifications as well.

8.5.1 Air-Handling Units

Fans and blowers for cooling and heating equipment are generally large-diameter, low-speed, low-horsepower (HP) and capable of maintaining the required system static pressure. Air-foil fan blades are preferred but backward inclined may be acceptable. Select and specify extra-heavy-duty, long-life bearings (minimum 50,000 hours) from standard bearing manufacturer charts provided by the fan manufacturer for the maximum published speed and HP rating of the fan. Select load-limiting (backward curved) wheels whenever practicable. High-velocity systems are discouraged, but if used, select fans that minimize surging and air noise. Present calculations, including temperature and altitude corrections. Select fans to operate on a stable portion of the curve. Discourage the use of small-diameter, long shaft fans except in small packaged equipment.

8.5.2 Motors

The minimum energy efficiency requirements for all single-speed, National Electrical Manufacturers Association (NEMA) Design B induction motors having nominal speeds of 1200, 1800, or 3600 rpm with open, drip-proof (ODP), or totally enclosed fan cooled (TEFC) enclosures, 1 HP or more shall comply with the requirements of table 10.2 of ASHRAE 90.1-1999 (matches NEMA Standard MG 1-1998). Motors for driven systems greater than 5 HP that operate for long periods of time (>3600 hours/year) may justify efficiencies which exceed the minimum requirements and should be evaluated for simple payback on new or retrofit installations.

Annual savings (S) = 0.746*BHP*$/kWh*annual hours operation* [(100/effA) – (100/effB)],

where effB is the efficiency (percent) of the higher efficiency motor.

An electric motor should be considered as always being connected to a driven machine, with specific operating characteristics, which dictate the starting and running load of the motor. As such, the motor selection is based on many factors, including the requirements of the driven equipment, service conditions, motor efficiency, power factor and initial cost. The driven system efficiency is the combination of the efficiencies of all the components of the system, e.g., the fan efficiency, the power transmission (belts), the air distribution system, and the motor controllers (such as Variable Speed Controllers [VSCs]).

Provide 3-phase motors for 1 HP and above. Provide across-the-line starters on smaller motors, and reduced voltage, auto-transformer, or other inrush, current-limiting, starter types on motors greater than 25 HP, or where system capacity or mechanical requirements indicate the need on smaller motor applications. Select motors with a sufficient rating for the duty they are to perform and not to exceed their continuous HP rating, including service factor, when the driven equipment is operating at its greatest HP. Coordinate starting and running characteristics with the driven machine and the motor control equipment. Motor enclosures shall be ODP for indoors dry locations and totally enclosed or totally enclosed fan-cooled for outdoor or wet locations, except where special conditions require otherwise.

Single-phase motors 1/8 HP and smaller shall be shaded-pole or permanent split capacitor; those larger than 1/8 HP shall be capacitor-start. Polyphase motors shall comply with NEMA Design B, unless other characteristics are required by the driven machine or the speed controller. Design motors for continuous service at 104°F (40°C) ambient temperature. Motors shall operate at full capacity, with a voltage variation of plus or minus 10 percent of the nameplate voltage. Consider high-efficiency motors where loading and continual use may result in significant energy savings.

Consider variable-speed controllers where motor speed requirements vary widely during normal operation. Solid-state, variable-frequency units are recommended for smaller HP motors. In all cases, select the motor in accordance with the drive manufacturer's recommendations to ensure a coordinated system and to avoid damage to the motor.

8.5.3 Pumps

Where circulating pumps are used in open systems such as cooling towers, install a suitable straining device (basket-type for base-mounted pumps) in suction lines and provide for easy removal to allow for cleaning. Connect all circulating pumps to the piping system through flexible couplings. Never connect a 90-degree elbow directly to the suction opening of any pump.

8.5.4 Air Filters

Air handlers shall be designed to accept bag type filters. Preferred size for filters is 24 inches x 24 inches x 15 inches deep, and the preferred media is fiberglass. Filter frame assemblies shall be specified such that there will be no leakage around the filters or filter bank. Farr Type 8 front-loading filter frames or Farr 3P Glide/Pack side loading frames, or equal, should be specified. Cartridge filters and slide rack frames are permitted in fan coil units and small roof

top air handler units. Filter banks shall be sized for no greater than 500 feet per minute face velocity.

General office area and light lab air handling equipment will use 50 percent efficient bag filters. Process, manufacturing, and special use area filter efficiencies will be determined by the project need. Air filters shall be rated either as Class 1 or Class 2 in accordance with UL900 Standard for Safety Air Filter Units and NFPA 90A.

Use only Class 1 filters in clean room applications. Nuclear Grade HEPA filters shall be listed under UL 586, Standard for Safety Test Performance of High Efficiency Particular Filter Units.

8.5.5 Humidifiers

Avoid humidifiers using a standing water reservoir. Equip all humidifiers with a drain-down, bleed-off, and overflow. Humidifiers supplied with non-potable water shall have a demineralizer tank installed to reduce scale build-up.

8.6 Plumbing Design

8.6.1 Design Conditions

Water main pressure is 60 to 110 pounds per square inch gauge (psig). Maximum water pressure varies depending on the location within the site. Consult with the systems engineer for design water pressures. Natural gas main pressure is 20 psig.

Flush valves shall have a 25-psig-minimum residual pressure; all other fixtures shall have a residual pressure of 15 psig minimum.

Water velocities shall not exceed 10 feet per second.

8.6.2 Potable versus Non-potable Water Connections

Supply Potable Water:

- To all plumbing fixtures except for fixtures located within a fume hood.
- To evaporative coolers and air washers, and provide an air gap between the supply and the flood rim.
- To landscaped (trees, lawns, shrubs, etc.) areas, and provide a vacuum breaker after the last valve (do not install shutoff valves downstream of a vacuum breaker).
- To eyewash and safety showers.
- To dishwashers and ice machines, and provide an air gap.
- To sinks with hose connections, yard hydrants, and hose bibbs. Provide with vacuum breakers.

Supply Non-Potable Water:

- To fume hoods
- To de-ionizing or de-mineralizing water systems
- To any connections provided in laboratory space for future use.

- To make-up water connections to circulated water systems.

Always consider the use of a distributed Non-Potable Water (NPW) system for multiple users as opposed to a Backflow Preventer (BFP) at each point of use. Make the decision based on life cycle cost. Refer to Chapter 7.3, Fire Protection Backflow Preventers, for backflow prevention requirements.

Provide signs at fume hood faucets and any outlet on the non-potable water system stating: **"Danger – Non-potable Water."**

8.6.3 Calculations Required

Hot and cold water systems:

- Demands in fixture units or gallons per minute
- Pipe sizing
- Shock absorber sizing
- Water heater storage capacity sizing
- Hot water expansion tanks.

For buildings with 50 or more occupants, base the selection of domestic water heaters on an economic balance of the maximum daily demand, the maximum hourly demand, the first cost and operation cost, and the availability and cost of fuel.

Sewer, vents, and drain lines:

- Load capacities (fixture units) to determine sizing
- Absorption rates for drain fields and seepage pits established by actual field percolation tests.

Gas supply system:

- Capacity used to size from tables in International Fuel Gas Code. (See Chapter 3 for exterior gas piping.)

Roof drains and piping:

- Rainfall rates (Sandia/NM=2 inches per hour)
- Flow rates
- Pipe sizing.

Backflow Preventers

- Sizing shall account for the head loss through the device at typical flow rates not to exceed 7.5 feet per second through the device.

8.6.4 Piping Materials and Labeling

Refer to Facilities Construction Standard Specification Sections 15051, Piping Systems, and 15401, Plumbing.

For selection of drainage piping in buildings that use corrosive chemicals, coordinate with the user to determine what corrosive chemicals will be drained, the temperature range of the effluent, and the amount of their dilution. Consult the Sandia Materials group or Environment, Safety, and Health when a possibility exists for a combination of corrosive chemicals to go into drains, and to determine the need for a neutralizing tank as a substitute for, or in addition to, corrosive drainage piping.

Construction Standard Specification 15401 specifies materials and installation requirements for "Laboratory/Process/Acid Waste and Vent systems that apply to systems so designated on the drawings. While no single material is capable of handling every chemical, the specification is based on either Polypropylene or PVDF with electric fusion joints. These materials are capable of withstanding corrosion from the widest number of chemicals but they may not be satisfactory for all conditions. The mechanical designer shall determine the appropriate material to be used based on the chemicals and their concentration, pressures and temperatures, system life and cost.

Identify piping with self-adhesive labels. Refer to Facilities Construction Standard Specification Section 15050, Basic Mechanical Materials and Methods.

8.6.5 Plumbing Fixtures

Standard plumbing fixtures (toilets, drinking fountains, sinks, etc.) are listed in Facilities Construction Standard Specification Section 15401, Plumbing. The designer shall specify special laboratory fixtures to meet customer's requirements. Flushometer valves for urinals and water closets shall be specified as Sloan or Zurn without exceptions.

8.6.6 Backflow Preventers

8.6.6.1 Design Conditions

Backflow prevention (BFP) assemblies are required to prevent cross-connection contamination between potable water systems and non-potable, potentially polluted, or potentially contaminated systems, such as drainage systems, soil lines, and chemical lines.

BFP assemblies are required to be approved by Sandia/NM and the Foundation for Cross-Connection Control and Hydraulic Research, University of California, and the International Association of Mechanical and Plumbing Officials.

Keep the number of BFP assemblies to a minimum through connection of non-potables on a common system.

Apply the devices in accordance with the following general guidelines:

- Atmospheric vacuum breakers must be installed on the discharge side of the last shutoff valve and a minimum of 6 inches above the highest overflow level.

- Vacuum breakers must be installed a minimum of 12 inches above the highest piping or outlet downstream of the device and must not be used where backpressure may occur. Discharge pressure should be maintained above 5 psig at all times.
- Double check-valve backflow preventer may be used if there is a possibility of backpressure, or if a low or nontoxic hazard exists.
- Use a reduced-pressure double check valve if there is a possibility of back pressure and a toxic hazard exists.
- Installation for the above backflow preventers shall provide the following:
- Positive drain for all discharges to an appropriate point with positive air gaps, as required
- Easy accessibility for testing and maintenance
- Protection from freezing
- Proper support when necessary
- Provisions for excessive pressure or thermal expansion downstream
- Placement between 12 inches and 60 inches above finished floor level.
- Configure the device to provide protection for high-hazard service with necessary check valve, relief valve, test cock, and isolation valve to conform to all codes having jurisdiction.

Refer to Chapter 7.3, Fire Protection Backflow Preventers, for sprinkler system backflow prevention requirements.

8.6.7 Calculations Required

Sizing shall account for the head loss through the device at typical flow rates not to exceed 7.5 feet per second through the device.

8.6.8 Plumbing–General

Provide building water pressure regulators for any building where the water system pressure is over 80 psig.

Provide building water flow meters for all facilities. Where possible, specify a meter which can report through the FCS system and provide a communication dataway to the device.

Provide suitable facilities for emergency quick drenching or flushing of the eyes and body in workplaces where occupants may be exposed to injurious, corrosive material. For all installations, involve the occupants' organization's Industrial Hygienist in selecting the type and location(s) for emergency eyewash and shower equipment. Generally, these will be:

- Positioned 100 feet or less from the hazard,
- Located in accessible areas that can be reached in 10 seconds or less,
- Labeled with a highly visible sign, and
- Illuminated with proper lighting (coordinate with electrical designer).

All eyewashes and safety showers shall meet the American National Standards Institute (ANSI) Z358.1 standard requirements. Hand-held drench hoses may provide support for emergency shower and eyewash units, but shall not replace them. Due to the infrequent of use of safety showers, floor drains generally are not required. Showers can be tested with a curtain and

bucket. Unless water is supplied directly from outdoors, tempered supply water also is not required. Refer to Facilities Construction Standard Specification Section 15401, Plumbing.

Water lines with solenoid valves, flush valves, or other quick-closing devices should be fitted with an accessible, valved and sealed shock chamber to absorb water hammer. Lengths of pipe that are capped to form air chambers are unacceptable.

Install wall hydrants 18 inches above grade on each major outside building surface, not to exceed 100 feet apart. Do not cast hydrants into masonry. Incorporate a vacuum breaker at each wall hydrant. Locate hydrants to insure that they will not be subject to freezing.

Do not cast any piping within the structure into concrete, except cast-iron sewers.

For future extension show service piping such as gas, compressed air, and domestic water (where applicable), with plugged tees instead of elbows. Provide isolation valves for ease of isolating sections of piping for future modifications without the need to shutdown most of the system.

Plumbing accommodations in government facilities shall conform to 28 Code of Federal Regulation, Part 36, Nondiscrimination on the Basis of Disability by Public Accommodations in Commercial Facilities. See Chapter 6.7, Accessibility Requirements, for further information.

Install a minimum of one floor drain per room in toilet rooms, darkrooms, janitor closets, and equipment rooms. Install adequate floor sinks, wherever needed, to take indirect wastes. Provide steam and valve pits with a French drain, 2 feet in diameter by 5 feet deep, filled with 1/2- to 1-inch clean, graded gravel. Coordinate with the structural drawings to ensure that floors are pitched downward toward all floor drains. Floor drain gratings shall be of heavy-duty construction and made from nonferrous material. Floor drain bodies shall be galvanized. Trapped floor receptacles shall be primed. Do not specify trap primers that rely on pressure fluctuations in the piping to activate the primer. Timed solenoid valves have been the most useful device for priming traps.

Do not connect floor drains to the storm drain system. The design team shall ensure by visual inspection, drawing search, and/or dye testing that plumbing connections are made to appropriate sanitary sewer piping. Do not make piping connection that would result in the flow of non-storm water to the storm drain system. Storm water is defined as those flows that result from atmospheric precipitation which have not been confined in any way (see Sandia/NM Environment, Safety and Health (ES&H) Manual). Consider the use of “water harvesting” for the discharge of roof drains on new facilities. Refer to section 3.6 – Drainage Requirements.

Detail roof drains in cross section and incorporate a suitable removable strainer or gravel guard, seepage pan, and clamping device. Connect the roof drains to the storm drainage system. Insulate roof drain piping in ceiling spaces.

Space sewer cleanouts to grade no further than 50 feet in buildings. Terminate each branch run in a full-size cleanout. Show sewer cleanouts on both the plan and isometric drawings. Locate cleanouts so a power-driven snake can be used without the need to relocate.

Make extensive use of re-venting, where practicable, to minimize roof penetrations. Hubless cast-iron pipe and fittings are acceptable above grade.

8.7 Heating/Cooling/Ventilation and Energy Calculations – General

Heating and cooling load calculations and energy and economic analysis shall be performed using Trane Trace 700 software. Analysis shall be performed early in the conceptual stages of the design to evaluate system size and compare alternatives. The analysis should also be performed for the as-designed conditions reflecting the construction, layout, and system configuration. Analysis of alternatives shall be based on life cycle cost analysis and consider first cost, maintenance, and energy cost as well as the project budget. The latest utility cost shall be obtained from the system engineering organization.

Provide ventilation to all occupied spaces to meet the requirements of ASHRAE Standard 62 'Ventilation for Acceptable Indoor Air Quality' latest addendum. Describe in the design analysis the procedures used and the necessary controls to meet the requirements

Calculations shall be submitted as a part of the Design Analysis that include the following;

- Narrative – Describing the type of construction, alternatives analyzed, assumptions for internal loads, airflows, construction, and schedules and supporting documentation.
- Drawings, sketches and schematics – Fully describe the zoning layout, system configuration, and construction types as referred to in the program.
- Reports – Provide the reports necessary to document the design decisions.
- Archive Files - FILENAME.TRC - The project file that contains all the information you entered into the program, including project, weather, room, system, zone, and load parameter information and any Project Templates that you used for entering room information. It also contains the results of the design calculations.
  LIBRARY.DB (optional) - The library database that contains all the information from the libraries that the program uses (Weather, Schedules, Construction Types, Glass Types, Materials, Internal and Airflow Loads, and Shading), plus all of the Global Templates. Note: You only need to archive this database if your project file uses "custom" library members, e.g. a library member that you created.
- Provide calculations to support the ventilation levels the system and individual spaces.

8.8 Heating Design

8.8.1 Design Conditions

Unless otherwise specified in the Design Criteria, use the tabulated weather data tables in the American Society of Heating, Refrigeration, and Air Conditioning (ASHRAE) Fundamentals volume per the following: Laboratory Occupancy 99 percent column, Personnel Comfort 97.5 percent column for outdoor temperatures.

Infiltration, except where exceeded by ventilation, should be taken into account by using the air-change method outlined in the ASHRAE guide. Pressurize all structures to approximately 0.03 inches of water to minimize infiltration, except where noted in the Mechanical Design

Criteria. The minimum outside air required to provide ventilation for each zone shall be in accordance with the latest edition of ASHRAE Standard 62. Include an additional air allowance for pickup when sizing boilers and converters. Systems shall not be additionally oversized unless otherwise noted in the Design Criteria.

Do not take credit for the heating contribution of light fixtures when sizing heating equipment for buildings that will be partially occupied during nonwork hours. Full credit will be taken for buildings that are occupied during working hours only.

In Tech Area I at Sandia/NM, use district steam only when life-cycle cost effective considering complete Steam Plant shut-down by the year 2012. In general, systems should be planned to migrate to decentralized hot water boilers.. Use gas fired hot water boilers as the primary source of heat for new and renovated buildings. Provide proper zoning so areas will not overheat as the result of winter sun and/or interior room heat that affects only part of a zone.

Design heating water systems with 180°F maximum supply temperature and a 20-40°F drop.

8.8.2 Calculations Required

Heating Systems:

- Heat loss by rooms, zones, and buildings
- Capacity of the distribution systems
- Heat-generating and heat-transfer equipment
- Hydronic calculations
- Pump sizing
- Fan sizing.

Fouling Factors:

- Present calculations to show the effects of fouling factors on either side of heat-exchange surfaces.

8.8.3 Piping Materials

Refer to Facilities Construction Standard Specification Section 15051, Piping Systems.

8.8.4 Heating System–General

Where possible, install local gas fired hydronic heating systems.

Size steel boilers by matching the net Steel Boiler Institute output ratings, corrected for altitude, with the calculated heat loss for the structure. Use net IBR ratings (Institute of Boiler and Radiation Manufacturers on Hydronics Institute) for cast-iron boilers or 30 percent allowance for pickup on other types of boilers and converters.

Boiler selection shall be by life-cycle cost and shall include the significantly different life expectancy and efficiencies of boiler types. Estimates of seasonal efficiency shall consider the effect of type of control, (on/off, high/low/off, fully modulating), number of boilers, and oversizing. Leave spare floor space for future expansion.

Use an outdoor reset water temperature control through the FCS to provide hot water supply temperatures according to outside air conditions without overheating.

In heating water systems, the control scheme shall cause the heating water pumps to operate only when there is a call for heating and to shut down during unoccupied hours. See Chapter 8.23, Controls.

Design all large heating water distribution systems that use a two-pipe, reverse-return primary system. In large buildings, give consideration to a primary and secondary system.

For water treatment requirements for heating water systems refer to the Water Treatment section later in this chapter.

Air vents on exposed hot water lines over 7 feet above the floor shall consist of ¼-inch copper tubing extended down to a petcock located 7 feet above the floor. Vents on hot water lines above ceilings need not extend below the ceiling.

Show flow-limiting devices and isolating valves for each use point. Size the piping so a minimum use of balancing valves will be required. Diverting tees are acceptable, provided the drop in main temperature is taken into account. Make extensive use of insertion test plugs to assist in balancing. Install flow meters or other flow measuring devices to indicate rate of flow in each system and zone. Use flow meters on small systems up to 10 gallons per minute. Use Delta P venturi fittings (less meter) on larger systems. Use a pumped coil for freeze protection on outside air applications.

Give special attention to wind pressure in warm air distribution systems, noting that severe winds are experienced at Sandia/NM. Incorporate features or zoning so the major portion of air will travel to the upwind side of the structure where it is needed most.

Gas-fired heaters shall have double wall vents and 100-percent stainless steel heat exchangers when 100-percent outdoor makeup air is used. Combustion air is not to be taken from the occupied space. Direct-fired makeup air handler units shall not be used without approval of the systems engineer. Direct-fired makeup units should not be used for makeup air to a chiller plant due to the possibility of vented refrigerant reacting in the gas flame.

Provide electric duct heaters, where required, with a manual and automatic reset, high-limit control, and a differential pressure switch (or other flow sensing device). Stage electric heaters.

8.8.5 Air Emissions Permits

In accordance with Section 17B of the Sandia/NM ES&H manual, gas fired equipment will require an air permit for Bernalillo County before construction can begin if;

- Actual emissions of a regulated air contaminant greater that 2,000 pounds per year
- Potential emissions of a regulated air contaminant greater than 10 pounds per hour

As soon as the mechanical designer has designed the heating system, selected equipment, and determined that either of these limits will be exceeded, the Sandia/NM Project Manager shall be

notified of the need for an air permit and provide with the specifications of the gas fired equipment. Contact Organization 3121, Environmental Management, for questions concerning air emissions and additional details. Obtaining a permit may take up to 180 days.

8.8.6 Boiler Controls

All boilers less that 12.5 MMBTU/hr input rating shall meet the requirements of ASME CSD-1, 'Controls and Safety Devices for Automatically Fired Boilers'. Boilers 12.5 MMBTU/hr and larger shall meet the requirements of NFPA 85.

8.9 Evaporative Cooling Design

8.9.1 Design Conditions

Applications to be considered are as a supplemental source of cooling for office and lab applications; and, should be considered as primary cooling for warehouses, shops not requiring close (plus or minus 5°F) temperature controls, nonresidential-size kitchens, makeup air ventilation units, and mechanical equipment spaces.

Spray pumps shall be located outside of the air stream when used in process exhaust systems and for any air handling system requiring 24-hour, 7-day-per-week operation.

Specify indoor design dry bulb temperatures for spaces air conditioned by adiabatic cooling systems by project-specific criteria. Operating efficiency for adiabatic cooling equipment shall be a minimum of 70 percent. Base the system-installed capacity on the conditioned space peak design cooling load. Do not use an arbitrary air-change rate for design airflow. State adiabatic cooler specifications in terms of air capacity, the entering ambient dry and wet bulb temperatures, and leaving dry bulb temperature.

When evaporative coolers are installed as supplemental cooling in an air handler unit, they should be installed downstream from the chilled water coil and controlled to operate as a first stage of cooling whenever the outside air dew point is below the highest allowable space dew point. The chilled water valve would then be modulated to maintain the required supply air set point. This setup will allow the use of warmer chilled water temperatures, more frequent use plate & frame heat exchangers, and more efficient operation of chillers.

Consider air duct design, number, and location of coolers, and reliefs of the higher rate of air supply (for two-speed fan operation) to the atmosphere to ensure a satisfactory operating system. Also, consider multi-stage indirect evaporative cooling systems.

8.9.2 Calculations Required

- Heat gains by rooms, zones, and building
- Capacity of distribution systems
- Psychrometric analysis (trace process on chart corrected for altitude)
- Heat dissipating equipment.

8.9.3 General

Specify drip-pad coolers on small installations where the use of fan curves is not required in the design. Specify high-efficiency rigid media coolers with stainless steel water sumps on medium and large size systems and where fan curves are needed in the design.

For energy conservation, specify the lightest color available from the manufacturer for the exterior finish coat of the cabinet.

Specify two-speed motors on all fans serving evaporative cooling equipment.

Detail a bleed, overflow, and drain on the piping diagram for each piece of evaporative equipment. Set the bleed amount for 1 gallon per minute per 1,000 cubic feet per minute of air flow. Arrange overflow and drains so fan suction does not empty a trap and thereby allow sewer gases to be pulled into the system. Inactive traps shall not evaporate the water seal with the same result. Discharge the bleed line to a sanitary sewer.

Detail a system for thoroughly draining (without the use of tools) supply-water piping that is subject to freezing. Include a slide damper in the design of small evaporative units. Install a spare set of guideways on the duct or other similar structure to provide for summer storage of the slide damper. When larger units are included and motor-operated dampers are used, the slide damper guideway is installed upstream of the evaporative section. Provide access doors to facilitate working on the evaporative media, the pumps, motors, etc.

8.10 Refrigeration Design

8.10.1 Design Conditions

For calculating building cooling loads, unless otherwise specified in the Design Criteria, use the tabulated weather data tables in the ASHRAE Fundamental Volume per the following: Laboratory Occupancy 0.4 percent dry bulb and 0.4 percent wet bulb column; Personnel Comfort 1 percent dry bulb and 2 percent wet bulb column. Size cooling towers and air-cooled condensers for the maximum actual conditions to which they are subjected.

Unless otherwise mentioned in the criteria, inside design conditions for personnel comfort shall be the 1 percent outdoor design dry bulb conditions, 72°F dry bulb. Comply with ASHRAE 90.1 for sizing of equipment and component. Present other indoor temperatures and humidities that are required for process or sensitive equipment in the Design Criteria. Present complete room-by-room and zone-by-zone heat-gain calculations. In general, pressurize all structures to minimize infiltration.

8.10.2 Calculations Required

- Heat gain by rooms, zones, and building
- Capacity of the distribution systems
- Heat-dissipating equipment
- Hydraulic calculations
- Psychrometric analysis (trace process on a chart corrected for altitude)

- Code Analysis proving compliance with the International Mechanical Code for refrigerant quantity limits and any need for a machinery room. Provide calculations for normal and emergency ventilation rates of machinery rooms.

Calculations for sizing chillers and supply-air quantities shall take into consideration both space and building electrical loads. The electrical loads are obtained from the electrical designer, who will determine loading from the electrical drawings and partial loading from the energy schedule in the Design Criteria. Modify the laboratory equipment portion of the full-load quantities to actual loading values by an appropriate diversity factor. Consult Sandia/NM Facilities Engineering to determine this factor. The equipment shall not be sized for future additional capacity or redundancy unless indicated in the Design Criteria.

8.10.3 Piping Materials

Refer to Facilities Construction Standard Specification Section 15183, Refrigeration Systems.

8.10.4 Refrigeration System—General

Show detailed provisions for draining condensed moisture from the cooling coils to a floor drain. Pay special attention to showing how the moisture is collected as it comes off the coil.

For built-up systems, use a control diagram to describe the appropriate safety, temperature, and pressure controls. Each reciprocating compressor shall have a high- and low-pressure cutout, low-oil-pressure cutout, and low-temperature cutout (to prevent freezing of tubes in water chillers). Where capacity reduction is needed at low loads to prevent short cycling, use automatic unloaders and/or properly staged multiple smaller compressors. Where possible, avoid using energy-wasting hot gas bypass designs. Install a time delay to prevent short cycling.

Fit compressors that are 5 hp and greater with an elapsed running time meter.

Heat rejection devices such as air-cooled condensers are preferred, except where size and equipment dictate the use of cooling towers. Select air-cooled condensers at least one size larger than determined by calculations, with corrections for altitude when the condenser is installed on roofs that experience high temperatures. Specify cabinets for air-cooled condensers with the lightest color available from standard manufacture. Specify a minimum ground clearance of 12 inches for condensers over 3 tons installed on grade. Smaller condensers should be installed on concrete pads or rails at least six inches above grade. Specify hail guards for all exposed condenser coils. Unless required by space or cost restrictions, locate air-cooled condensers away from direct sun exposure and where they will be suitable for operation at low ambient conditions. Pay attention to oil return and where equipment must operate in cold weather. Provisions must be made to guard against low-head pressures and backslugging of liquid (low ambient protection). Where short-cycling or capacity reduction can become a problem provide several smaller compressors. To prevent freeze-up and extend the life of the cooling towers, provide a sump tank on cooling towers being used for year-round cooling. Include an automatic condenser water temperature control to maintain optimum refrigeration equipment operating efficiency. Specify cooling towers constructed of fire-resistant materials.

Air-to-air heat pumps are permitted for T-buildings or mobile offices only or to transfer energy within a building.

Design medium to large chilled water systems using either a two-pipe, reverse-return flow, or oversized mains and with a 10-15°F temperature differential. When a primary-secondary system is designed, additional circulators are required on each secondary loop. Consider variable flow systems with variable speed pumping in systems over 100 tons. In constant flow systems, install flow controllers and heat exchange devices (coils, etc.) in each zone. Although balancing valves are generally not necessary in variable flow systems, they can be useful for troubleshooting problems later. Use Bell and Gossett circuit setters on small systems up to 10 gallons per minute. Minimize the use of balancing valves in variable flow systems.

Refer to Chapter 8.28.2 for water treatment requirements for chilled water piping.

Air vents on exposed chilled water lines over 7 feet above the floor shall consist of ¼-inch copper tubing extending down to a petcock located 7 feet above the floor. Vents on chilled water lines above ceilings do not need extending down to below the ceiling.

Specify Air Conditioning and Refrigeration Institute certified water coils. Size coils for 500 feet per minute maximum face velocity.

Two-way water control valves are preferred over three-way valves, except that a minimum number of three-way valves shall be used to provide the minimum flow needed for chillers. Use series and parallel pumps with automatic controls to limit the valve differential head increase to twice the initial head. Systems with lower heads (60 to 70 feet) shall use parallel arrangement. Systems with higher heads shall use a series arrangement.

Wherever possible, include economy cycle provisions in the system.

Choose refrigeration equipment to comply with the minimum coefficient of performance ratings as listed in ASHRAE Standard 90.1. New equipment should be limited to using refrigerants classified A1 or B1 by ASHRAE Standard 34 and either hydrofluorocarbons or hydrochlorofluorocarbons. Typical refrigerants meeting these requirements are R-22, R-123, and R-134a.

Design refrigeration systems to meet the requirements of the International Mechanical Code.

8.11 Refrigeration Machinery Rooms

When a refrigeration machinery room is required design the room to meet the requirements of the IMC and related sections of the IFC.

8.11.1 Architectural Requirements

The mechanical designer shall insure that the architectural requirements for a machinery room are met the by the design team. Pay particular attention to the following issues;

- Tight construction to prevent migration of vapors to others parts of the building.
- Tight fitting doors opening outward with self-closing devises if they open into the building
- Adequate number of exits located to ensure freedom for persons to escape in an emergency.

8.11.2 Refrigerant Detection and Alarms

Provide both audio and visual alarms both inside the machinery room and outside each entrance. The horn and strobe shall have a different tone and color than that used for fires.

Provide refrigerant specific detectors for each type of refrigerant used by equipment used in a machinery room.

The detector shall have a means of manual reset. Remote reset is required if the detector is installed outside of the machinery room.

Pay particular attention to the location and number of intake points of sensors needed to detect a refrigerant leak. Locate sensor points 12-18 inches above the floor and in any pits that could be occupied where refrigerant could accumulate. A sensor point may be placed between two systems with the same type of refrigerant. Locate sensor points down stream of the system in the direction of ventilation airflow.

A multi-channel scanning system may be used for multiple systems with the same refrigerant type.

Refrigerant detectors specified with the following;

- Three levels of alarms plus a trouble alarm utilizing individual relays with 240 VAC 5 amp resistive SPDT contacts. Each relay shall be capable of being latched to a manual reset.
- Refrigerant specific sensor technology such as photoacoustic or non-dispersive infrared. Linearity greater than or equal +/- 5 ppm in the 20 to 100 ppm range, or +/- 6% of reading in the 100 to 1000 ppm range.
- A 4-20 ma analog output shall be tied to the FCS control system.

8.11.3 Ventilation

Provide both normal and emergency ventilation using outdoor supply and exhaust with a system that is independent from the remainder of the building. Normal ventilation air shall be tempered to maintain a temperature between 65-85 degrees F. Emergency ventilation air shall be heated sufficiently to prevent pipes from freezing with the machinery room. Exhaust air shall be discharged to a safe location outside the building. Normal ventilation shall be based on 0.5 CFM per square foot of machinery room area. As long as temperatures are maintained the normal ventilation may be switched by an occupancy sensor such as a light switch or motion detector.

The ductwork shall be arranged with inlets and outlets placed to provide a sweeping of air past equipment with no dead spaces.

Emergency ventilation shall be started by a high level alarm in the refrigerant monitor and also by switches placed outside of each entrance.

8.11.4 Alarm Levels

Alarm levels and responses shall match the following tables:

Refrigerant	"Caution"	"Alert"	"Alarm"	"Trouble"
R-11	50 PPM	250 PPM	700 PPM	Sensor/Controller Fault
R-22	50 PPM	250 PPM	700 PPM	Sensor/Controller Fault
R-134a	50 PPM	250 PPM	700 PPM	Sensor/Controller Fault
R-500	50 PPM	250 PPM	700 PPM	Sensor/Controller Fault
R-123	30 PPM	40 PPM	50 PPM	Sensor/Controller Fault
R-407c	50 PPM	250 PPM	700 PPM	Sensor/Controller Fault

	Panel Alarm	FCS Alarm Message	Alarm Priority & Action
Alarm Level 1 Contacts	CAUTION	Building ___ Refrigerant Level CAUTION. Level has reached ___ ppm in the equipment room. Leak check the refrigerant system.	Priority 6 alarm (FCS alarm at the building operator's control terminal. Operator Actions: Leak detection, portable gas detector optional, and no respiratory protection required.
Alarm Level 2 Contacts	ALERT	Building ___ Refrigerant Level ALERT. Level has reached ___ ppm in the equipment room. Immediate Attention Is Required.	Critical alarm message to the Steam plant. Ventilation system is automatically started. Operator Actions: Leak detection, portable gas detector optional, and no respiratory protection required. (BUT EQUIPMENT STAGED AND READY FOR USE)
Alarm Level 3 Contacts	ALARM	Building ___ Refrigerant Level ALARM. Level has reached ___ ppm in the equipment room. Immediate Attention Is Required. I.C. emergency response required. DO NOT ENTER THE EQUIPMENT ROOM WITHOUT A SUPPLIED AIR RESPIRATOR.	Alarm light beacons signal need to evacuate. Alarm horn sounds. Critical alarm message to the steam plant. Ventilation system is operating. Operator Actions: Leak Detection, portable gas detector required, supplied air respirator required.
Trouble Contacts	TROUBLE	Building ___ REFRIGERANT MONITOR TROUBLE. Refrigerant monitor is inoperative. Immediate attention is required.	Same priorities and actions as "Caution"

8.12 Exhaust Design

8.12.1 Design Conditions - General Exhaust

Thoroughly exhaust toilet rooms, darkrooms, battery rooms, and other areas that contain noxious, harmful, or objectionable fumes. In the design calculations, indicate the quantity of air exhausted and air made up to the area, balanced so a slight negative pressure exists to prevent exfiltration from the room.

Provide exhaust in restrooms to meet the requirements of ASHRAE 62. Provide exhaust for refrigeration machinery rooms to meet the requirements of the IMC for normal and emergency ventilation rates.

Use sight-proof and nonadjustable door louvers. Use special exhaust grilles and door louvers in darkrooms to prevent passage of light.

8.12.2 Design Conditions - Local Exhaust Ventilation

Local exhaust ventilation (LEV) is preferred over dilution ventilation for controlling hazardous vapors, gases, and particles. The Local Exhaust Ventilation Program is managed by the

Industrial Hygiene Department (3122). Industrial hygienists are assigned to respective Sandia/NM line organizations requesting work, and are knowledgeable about the operation and conditions of exposure. They are an essential source of information during the design of the LEV system. Refer to the ES&H manual (Chapter 6, Section P) for additional information about LEV systems.

Clearly define the source of all exhaust air, and provide clean, tempered air into the space to replace exhaust air. The designer shall assist the line organization and Industrial Hygiene in the selection of exhaust hoods and controls for each application, and the exhaust system for which the hoods are to be used.

Design hoods, and calculate exhaust requirements based on similar applications found in "Specific Operations" of the latest edition of the American Conference of Governmental Industrial Hygienists' Industrial Ventilation Manual or Sandia/NM's Mechanical Standard Drawings. All "non-standard" LEV designs require an Industrial Hygiene review. Non-standard is defined as a design that does not appear in common reference text such as the Industrial Ventilation Manual.

The location of the fume hood within a space can have an impact on the effectiveness of the exhaust equipment. The mechanical designer shall provide guidance to architectural designers on layout requirements for fume hoods. Locate fume hood faces 10 feet or more from the closest air supply or exhaust point, but not in or along normal traffic routes. A fume hood should not be located where room air currents greater than 50 linear feet per minute will disrupt uniform air entrance at the hood face.

Fume hood face velocity depends on the capture containment requirements of the hazard, room supply air distribution, traffic past the hood, and the amount and location of equipment in the hood. Fume hood full-open-area face velocity settings can be between 80 and 100 feet per minute, depending on the quality of supply air distribution, the level of hazard, and the quality of the fume hood. Generally, a face velocity of 100 feet per minute is satisfactory if the quality of supply air distribution is adequate, traffic past the hood is low, and there is no equipment in the hood closer than 6 inches to the hood's face. Regulated carcinogens and radiological hoods require higher face velocities.

All fume hoods require an airflow indicator: a simple vanometer, differential pressure gauge, or a more complex Variable Air Volume (VAV) control system. Coordinate with the Sandia/NM line organization to determine which device to use, and whether to order it with the hood or install it during construction.

Systems handling particles require that minimum transport velocities be maintained throughout the system. Although systems handling vapors and gases have no minimum duct velocity criteria, duct velocities of 2000-3000 feet per minute usually result in a good balance between initial and operating cost. Use round ducts for exhaust systems whenever possible. Round ducts resist collapse, provide better aerosol transport, seal easier, and use less metal than rectangular ducts.

Provide separate exhaust systems for process exhausting of incompatible hazardous fumes, gases, etc. Specify the type of duct material and coatings to use throughout the system, compatible with the material being exhausted. Consult with Industrial Hygiene when unsure of how chemicals will react.

Calculate exhaust requirements for closed-type glove boxes for 50 cubic feet per minute (minimum) per glove box.

Exhaust vacuum-pump-oil mist to the outside, or to the building exhaust system.

For nuclear exhaust applications, refer to the Nuclear Air Cleaning Handbook for additional requirements.

Exhaust system flow schematics shall be prepared for all systems with multiple exhaust hoods. Existing flow schematics shall be modified to reflect all changes made to exhaust systems. Schematics shall indicate each source of exhaust, room number, type of hood, design flow rates, riser flow rates, fan flow rates, dampers, filters, and all other components of the exhaust system.

8.12.3 Exhaust Fans

Calculate the *total pressure* requirements for sizing exhaust fans. Account for system effect losses, and lay out the supply and exhaust connections to fans to reduce the system effect losses as much as practical.

Roof exhausters for general room exhaust shall be all aluminum, roof-mounted, curb-type, and centrifugal, with an integral weather cover, bird screen, back-draft damper, and roof disconnect. Mount the motor outside the air stream. Direct connection is preferred.

Specify the following operating conditions (altitude = 5500 feet) for roof-type exhaust fans:

- Air quantity
- Static pressure
- Motor hp and rpm
- Fan wheel size

Exhaust fans that serve acid, corrosive, or other fume hoods shall be utility-type, and epoxy-coated. Discharge fumes vertically upward at an exit velocity of 3000 feet/minute at a location and height sufficient to prevent re-entry of hazardous fumes. Extend exhaust stacks at least 10 feet above roof level or air intakes that are within 50 feet. Do not install a weather cap on stacks that discharge hazardous chemicals. Final determination of exhaust stack height shall be based on the ASHRAE Handbook of Fundamentals, “Airflow Around Buildings,” to effectively dissipate effluent.

Coordinate design with structural and electrical designers to ensure proper stack support and lightning protection.

8.13 Ductwork Design

8.13.1 Design Conditions

Unless otherwise mentioned in the Design Criteria, design supply ductwork using the static-regain or equal friction method to ensure that design quantities of air will reach final outlets in the system. Examples of static-regain and equal friction system design are outlined in the ASHRAE Handbook of Fundamentals and the Carrier Corporation Design Manual.

Design return-air and exhaust systems in accordance with principles of equal pressure drop. This method ensures that proper air quantities will be returned from even the most remote opening. (Every path of air being removed from a particular area or room shall have the same pressure drop back to the fan inlet.) Coordinate ductwork layout with the structural designer to minimize penetrations through firewalls and fire-rated partitions. At these penetrations, fire and smoke dampers and access doors are required.

Specify that Duct Coordination Drawings be submitted on larger and more complicated system as per Standard Construction Spcecification15810 “Ductwork” Section 1.03, 'Submittals', when the design drawings cannot adequately show all the possible interferences.

Consider the requirement for a return air fan when return duct resistance exceeds 0.25 inches of water.

Duct run distances shall be as short as possible. Size the runs on the critical pressure path for minimum practical pressure.

Select diffusers for their ability to quickly mix supply air with room air introducing a maximum of supply air with a minimum throw. Ensure that airflow does not short circuit from the supply diffuser to the return-air openings. Avoid using combination air supply and return diffusers.

During design, select the throw from each diffuser so the throw is 90 percent of the distance from the diffuser to the nearest wall or other obstruction. In the case of diffusers with a downward vertical air pattern, select the throw to terminate above breathing level.

Provide means for balancing the air systems. Devices shall include but are not limited to dampers, flow measuring stations, temperature and pressure test connections, gauges, and flow sensors. Provide permanently installed devices on major equipment. Air monitoring devices shall be multi-point devices that can continuously measure total and static pressure.

8.13.2 Calculations Required

Present calculations for the design of all air-handling duct systems:

- Duct sizing
- Fan sizing
- Size dampers that admit outside air by pressure drop, rather than face velocity. Calculate the largest drop from a return air register, then make the damper drop an equal value
- Noise criteria (noise criteria curves).

8.13.3 Ductwork-General

Refer to Facilities Construction Standard Specification Section 15810, Ductwork, for sheet metal gauges, materials, equipment, and methods to be used, and the construction of ductwork.

Draw ductwork to scale (single-line diagrams are not acceptable). Thoroughly dimension the drawings. Clearly show register size, equipment list number, cubic feet per minute, pressure drop, and throw. Show all turning vanes in elbows, transitions, duct liners, and air proportioning vanes.

Diffuser size, cubic feet per minute, and throw should appear on plan drawings for each type and size of diffuser. Refer to diffusers with volume controls affixed to the upstream side as registers. A diffuser or return-air device with no volume control may be referred to as a grille. Identify noise criteria ratings in equipment lists.

Install access covers on both sides of heat-exchange devices in ducts. Ensure adequacy for complete cleaning and servicing.

A plenum ceiling return may be used where feasible.

Install fire dampers in all ductwork passing through firewalls, between floors, and where dictated by code requirements. Provide all fire dampers with standard commercial and catalog-listed access doors. For duct areas smaller than 1 sqft. provide a removable section of duct to fully access the fire damper.

List the required duct pressure classification required for each duct segment on the schematic drawings. Unless otherwise stated on the drawings, Specification 15810 Ductwork, will require the following pressure classifications;

- From the fan to the VAV box – 4” w.g. positive
- Downstream of the VAV box – 1” w.g. positive
- Return air – 1” w.g. positive or negative
- Lab exhaust – 4” w.g. negative
- Restroom and general exhaust – 2” w.g. negative

For pressures less than negative 4” w.g. or greater than positive 10” w.g., and for highly corrosive exhaust, ductwork shall be constructed to SMACNA Round Industrial Duct Construction Standards of SMACNA Rectangular Duct Construction Standards. In these situations the designer is required to specify other operating criteria for the contractor to use in applying the standard such as materials, joint type, exterior loads, maintenance loads, corrosive environment.

Provide duct support details for ducts located on the exterior of the building and for all equipment.

Fire and smoke dampers shall be specified for "Dynamic Closure" in a fire event to shut off against airflow at a minimum of 2375 FPM and 4 in.wg. for horizontal or vertical flow.

For large and more complicated jobs, the designer, in accordance with Specification 15810 Ductwork, may request shop drawings, duct reinforcement information, and hanger details. This additional information must be requested through the submittal list.

8.14 Compressed-Air System Design

8.14.1 Design Conditions

Normal Shop and Controls – Pressure: 125 psig.

Laboratory and Special Use – Determine the pressure based on equipment requirements.

8.14.2 Calculations Required

- Capacity and pressure drops
- Storage capacity
- Percent of running time for the compressor selected.

8.14.3 Piping Materials

Refer to Facilities Construction Standard Specification Section 15051, Piping Systems.

8.14.4 Equipment

For normal shop and control air applications, the compressor shall be a two-stage, air-cooled, pressure-lubricated, motor-driven, tank-mounted unit. For units above 15 hp, a water-cooled model is indicated and a separate vertical air receiver is preferred. The compressor shall be capable of delivering rated cubic feet per minute of free air at the design altitude. Laboratory applications may require clean, dry compressed air from oil free rotary screw or rotary lobe compressors or oil lubricated rotary compressors with high efficiency oil removal filters and dryers.

The receiver shall be ASME National Board registered, rated, and certified, and stamped for 200-psig working pressure. In extended distribution systems, show auxiliary receivers at remote points. Receiver tanks between 18 and 36 inches in diameter shall have two 4- by 6-inch handholes at each end of the shell. Tanks over 36 inches in diameter shall have a 12- by 16-inch manhole. Install air receivers so all drains, handholes, and manholes are easily accessible. Show details of tank support.

Install ASME-approved relief valves, preferably on the receiver or at the output of the compressor. Set for the rated working pressure of the most vulnerable portion of the system, that is, the receivers. These relief valves shall be 3/4-inch National Pipe Thread or larger and have an outside lifting lever. Relieving capacity shall be larger than the compressor displacement.

Systems 5 hp and greater shall be provided with an elapsed-run time meter.

When two or more compressors are installed, install a means to efficiently operate the compressed air system.

Gauges on receivers shall have a range equal to 1-1/2 times the safety valve setting.

8.14.5 Compressed-Air System–General

Size the distribution system to provide extra storage capacity at times of maximum demand and to provide for possible future expansion of the system. Show valved drip legs at low points in the system.

Install a refrigerant air dryer for air compressors 5 hp and greater. If available year-round, run chilled water through an after-cooler. If chilled water is not available, use a self-contained refrigerant dryer. Use a float trap to remove any condensed material above a drip leg before the material enters the receiver. Drain the low point in the receiver with a timer operated solenoid valve

The first 4 feet of service line from the tank of a tank-mounted air compressor shall be reinforced braided flex connections. Install larger, water-cooled models having separate tanks with lengths of flexible metal hose in two planes, one of which is installed between the compressor and the aftercooler and parallel to the compressor crankshaft.

Wherever possible, large air compressors should take their air from outside the building through a suitable oil filter.

8.15 Pressure Systems

8.15.1 General

Sandia defines a pressure system as an assembly of pressure-containing components typically consisting of pressure vessels, piping, valves, pumps, instruments, etc., which are capable of maintaining fluid (liquid or solid) at a pressure different than atmospheric. This definition is intentionally broad to include the variety of systems with both positive pressures and vacuums that can present hazards to individuals and facilities.

The Sandia facilities organization is responsible for designing a wide variety of pressure systems that ultimately are owned, operated, and maintained by either the facilities organization or a line organization.

In an effort to provide a safe environment for pressure related applications Sandia has instituted a Pressure Safety Program that contains policies for all designers, installers, and operators of pressure systems. The mechanical designer of a pressure system is responsible for meeting the requirements of the Pressure Safety Program as contained in the Pressure Safety Manual. The program and manual are located at psi.sandia.gov.

8.15.2 Minimizing Risk and Exposure

The design shall consider the following techniques to achieve minimal risk and exposure to the hazards of pressure systems:

1. Identify all hazards and consequences.
2. Minimize pressure and volume.
3. Use recognized standards.
4. Design conservatively
5. Use materials with predictably safe failure modes. Brittle materials sometimes fail unpredictably.
6. Demonstrate structural integrity by overpressure test.
7. Operate within the original design intent.
8. Provide backup protection.
9. Use proven hardware.
10. Use protective shields.
11. Use tiedowns.
12. Go “remote”.

8.15.3 Pressure Limitations

The mechanical designer shall review the pressure limitations of all components and their relationship to the following levels of pressure:

- System Operating Pressure
- Set Pressure and Opening Range of Relief Devices
- Maximum Allowable Working Pressure (MAWP)
- Overpressure Test Pressure
- Predicted Failure Pressure

Sandia Facilities Standard Construction Specifications have been developed to meet the requirements of the Pressure Safety Program for their intended systems. The designed shall consider the limitations of each standard specification before selecting it to use for a new system or modifications to an existing system. When any new system will operate outside the range of the standard specifications the designer shall either modify the standard specifications or create a new specification that incorporates all of the requirements and intent of the Pressure Safety Program.

8.15.4 Data Package

A data package is required for all pressure systems. It contains information on the system description/hazards and contains ratings, materials of construction, and documents the configuration of the system. For most facilities owned systems the requirements of the data package are contained in the facilities drawings, specifications, and component submittals and no additional effort is required to prepare the package. For systems owned by a line organization the designer shall assist the owner in preparing the data package by forwarding drawings, specifications, and submittals to the owner upon completion of the project.

8.16 Special Gases

See the Design Criteria for design conditions and required calculation.

All compressed-gas cylinder valve outlet and inlet connections shall conform to the standard of the Compressed Gas Association Standard V-1.

Provide gas cylinder wall racks for gas cylinders at all manifold and storage locations.

8.17 Pressure Vessels

8.17.1 Design Conditions

All vessels shall conform to the ASME Code, including Section VIII, Division I. All vessels shall be ASME National Board certified, registered, and stamped, and meet the impact requirements of UG-84 with no exceptions. Include the requirement for ASME Form U-1A, Manufacturer's Data Report for Pressure Vessels, in the list of required descriptive submittals. Pressure vessels shall be fully described in the equipment list. Include the statement, "No ASTM A-515, ASME SA-515-type steel will be used in the fabrication of this vessel," in the description and specifications.

8.17.2 Calculations Required

Present calculations on the sizing of all portions of the pressure vessels, including connections and fasteners.

8.17.3 Pressure Vessel–General

The pressure vessel detail drawing shall show all construction and installation dimensions and sizes. Provide a 2-inch plugged opening in the center of the head at each end of vessels under 18 inches in diameter. Use openings for inspection purposes only. Locate inspection openings for clear access. Maintain at least a 24-inch clearance in front of all access holes. Pressure vessels between 18 and 36 inches in diameter will have two 4- by 6-inch handholes at each end of the shell. Tanks over 36 inches in diameter will have a 12- by 16-inch manhole. Show the tank support structure on the pressure vessel detail.

Provide suitable tappings for a thermometer well, a pressure gauge, and a relief valve in addition to tappings required for service connections. Provide a 3/4-inch minimum tapping at the low point to facilitate complete gravity drainage of the vessel. Details of the tank shall show locations and sizes of all openings.

8.17.4 Above Ground Storage Tanks for Flammable and Combustible Liquids

Above ground storage tanks for flammable and combustible liquids shall be installed in accordance with the International Building Code (IBC), the International Fire Code (IFC) and NFPA 30. All plans concerning the installation or use of above ground storage tanks shall be submitted to Sandia/NM Fire Protection Engineering for review prior to installation.

8.18 Relief Valves

8.18.1 Design Conditions

Without exception, size the relief valve(s) to relieve the unregulated capacity of the PRV, burner, pump, and compressor or prime mover, with no more pressure accumulation than the appropriate code recommends. Factory set the PRVs at the pressure rating of the piece of equipment having the lowest working pressure for that section of the system. All relief valves shall be 3/4-inch minimum pipe size and have an external lifting lever. Set the temperature and pressure relief valve on domestic hot water systems for 125 psig and 210°F.

Because the unregulated capacity of devices manufactured by different companies may vary, do not call out the size of the relief valves on the drawings unless it is known beyond doubt (that is, existing installed equipment or Sandia/NM-furnished equipment).

From the manufacturer's regularly published ratings, report the unregulated capacity for a given device as unregulated capacity. The highest ratings shown in standard capacity tables are usually not unregulated and shall not be treated as such. Where the issue is in doubt, a letter from the manufacturer (not the local agent) is required.

In the case of steam-fired equipment, assume that a tube could break and the control valve could simultaneously deliver unregulated flow. Provide the water side with a relief valve sized to relieve the unregulated capacity of the steam control valve. A relief valve sized only for the capacity of the heat-transfer surface is not acceptable.

8.18.2 Calculations Required

Present relief valve calculations to show the maximum amount of medium in question to be released.

8.18.3 Relief Valves–General

Provide each steam, compressed air, compressed-gas, hot water, or hydraulic system with ASME National Board certified, registered, and stamped relief valves. Pipe the discharge from a steam relief valve to the outside in a manner that will protect passers-by when it discharges. Pipe liquid effluent from other relief valves to the nearest floor drain or floor sink through an air gap two pipe diameters of the supply inlet, but in no case less than 1 inch. Ensure that relief valves are not obstructed or prevented from discharging by other equipment.

8.19 Standby Equipment

Only when indicated in the Design Criteria (which defines design requirements for the specific project), install tower, chilled, and heating water pumps in pairs with suitable valving so one pump can be turned on within minutes while the other pump is taken off-line for repairs.

8.20 Bird Screens

Provide all exterior building mechanical and equipment penetrations with a 1/2-inch-mesh, galvanized bird screen. Provide insect screens to areas that handle food, service equipment, or do not have filters to stop insects. Locate screens so they can be easily changed or cleaned.

8.21 Equipment on Roof

It is preferable to locate air intakes and exhausts on roofs and orient them to minimize adverse wind effects. All outside intakes should be at least 15 feet from flues, sewer vents, and exhausts. Where air intakes or exhausts are located on walls or less than 2 feet above the roof peak, prepare detailed wind-pressure calculations and show the discharge of air at the various wind velocities. Thoroughly detail stacks and vents to show flashing and counter flashing.

If a curb other than those shown on standard detail drawings is used, then curb details shall appear on the architectural sheets. Set up items not suitable for curb mounting at a minimum of 18 inches above the roof surface on an angle-iron stand with steel-pipe legs (per architectural standard drawings) so reroofing can be done under them. Extend the stand's legs to the structural members and flash with flexible pipe boots or single-ply flashings where appropriate.

Provide walkway pads on the roof leading from the access door to mechanical equipment that requires regular service. Whenever mechanical equipment is roof-mounted, call out permanent access ladders leading to the roof, except where security measures dictate otherwise. Locate water-using equipment so

- Over-spray will not be a problem
- Equipment can be readily drained, will not freeze up, and can be easily worked on
- No short-circuiting of air will occur.

Provide at least a 6-foot clearance between roof-mounted equipment and the edge of the roof, or provide suitable pipe-rail guards.

The mechanical designer is responsible for transmitting accurate information concerning size, weight, and dynamic loadings associated with roof-mounted mechanical equipment to the structural designer.

8.22 Instrumentation

Drawings shall indicate self-sealing test plugs, pressure gauges, thermometers, flowmeters, draft gauges, thermometer wells, and other instrumentation so equipment performance can be evaluated without shutting the equipment down or resorting to portable instrumentation when installing necessary instruments. Instruments shall measure temperatures and pressure drops in and out of heat-exchange devices using in-line installed self-sealing test plugs. In addition, install a diaphragm-actuated, dial-type gauge to measure (in inches of water) the drop across all filter banks and fans, with the possible exception of fans in small packaged units. Supply outdoor units with weather shields. Use bimetal dial type thermometers for mounting in thermowells in the piping. Mount remote-bulb thermometers on a centrally located panel together with remote-bulb or sensing controllers. Show instrumentation on the flow schematics and details.

Remote monitoring and alarm instrumentation is done by an FCS. See Chapter 8.23.1, Facilities Control Systems.

8.23 Controls

8.23.1 Facilities Control Systems (FCS)

Sandia/NM uses a Landis & Siemens System 600 FCS with direct digital control, to monitor and control HVAC systems in the buildings. This FCS shall be included in the design of all facilities greater than 10,000 square feet, unless otherwise specified by Sandia/NM. Because of the unique design of this control system, all of the information pertaining to this system is provided below.

8.23.1.1 Specifications and Design Guidelines

The mechanical engineer issues the control discipline specifications. The following documents should be obtained before starting the control design:

- Project – Specific Design Criteria
- Facilities Construction Standard Specification Section 13943, Facilities Control Systems
- Sandia/NM Standard Drawings; MI5001STD, MI6001STD, MI6002STD

8.23.1.2 Monitoring

HVAC systems are monitored by a system of digital and analog sensors located throughout equipment rooms and at selected locations in the building. The sensors are connected through a system of conduits and wires to field interface devices (FIDs). Critical alarm conditions are also reported at the existing reader/printer in the Central Steam Plant, which is continuously monitored. These alarm points are selected by Facilities Systems Engineering with input from Facilities Operations and Maintenance.

8.23.1.3 Control

Control of HVAC systems is by start-stop functions and direct digital control (DDC) generated by the FIDs and host computer, unless the HVAC application (for example, fan coil unit) warrants conventional electronic controllers. Analog output control signals will be programmed into the FIDs and connected to the various damper operators, valve operators, motor starters, etc., by a system of conduit and wires. Drawings shall contain complete sequences of control for each system (cooling, heating, exhaust, domestic hot water, smoke removal, solar, etc.). The relay contacts in the FIDs are rated at 5 amps at 250 VAC. Smoke detectors and freeze stats should be hard wired to fan motors.

8.23.1.4 Smoke Removal and Fire Functions

The FCS does not respond to smoke, fire, or sprinkler water flow alarms unless the sequence of operations designates that a unit, such as a supply fan, which is already controlled by the FCS, change its mode of operation. When this is a requirement, provide a contact closure from the Fire Alarm Control Panel (FACP) or Signal Line Circuit (SLC) control module that alerts the FID to the situation. If additional requirements must be met, such as starting smoke removal fans (functions that are not controlled by the FID), then these requirements will have to be accomplished by other control means, such as a relay that operates off an FACP or SLC control module contact.

When packaged air handler units are provided with smoke detectors, the detectors shall meet the requirements of Standard Specification 13852 (Intelligent Fire Alarm Systems)

8.23.1.5 System Definition and Presentation

The following drawings are required to define and illustrate the monitoring and control systems described above. Sample drawings of each type are available upon request from FCS Office, Mechanical Systems Engineering Department, and may be used to illustrate the desired format, symbols, etc. The samples shall not be considered as standards and reused as such. The only formats that should be regarded as standard are the FID layout drawing and the point numbering scheme, both of which are available from the FCS Office. The mechanical engineer shall develop a full set to be used in construction.

Flow Diagram and Sequence of Operation Sheets

Develop these drawings in two phases. The first submission shall provide the flow diagram of the intended system configuration, the proposed sequence of operation, and the DDC point selection. This set defines the base system for approval. After this basic approach has been accepted, then the monitoring and alarm points will be selected by Facilities Engineering. After the complete point selection is accepted, the remaining FCS drawings will be developed.

Field Interface Devices Layout Sheets

These drawings illustrate the layout and termination of input and output field connections in the FID cabinets. Twenty-five percent capacity of each point type shall be reserved in the panels.

Point List and Definition Sheets: Input/Output (I/O) Summary

These drawings provide a compilation of the total points selected and show point nameplate data, reference drawings, device symbol and number, and device range (established by the designer).

Component Location Plan

These floor plans shall locate all components in a system (for example, FIDs, sensors, actuators for dampers, valves, motor starters, etc.) and the conduit that interconnect the items. A scale of 1/8 inch per foot or smaller is suggested to allow better coordination of the various items in the system. Keep all FID cabinets a minimum of 5 feet (1.5 meters) away from power sources greater than 100 kVA and any Variable Frequency Controllers.

Conduit Schedules

These sheets present the coordination of the wires contained in conduits between sensors and FIDs.

Control Ladder Diagrams

Provide ladder diagrams for each piece of equipment energized/de-energized by the FCS.

Equipment List

These drawings list only the equipment or components peculiar to the control discipline. Identify the items in a similar manner as other items but with a number enclosed in a diamond. Include the full specifications for ordering. Specify sensors that are totally compatible with the Landis and Siemens System and that are field calibratable. There are, however, many vendor sources to provide competition for bidding. A sample listing of sensors of high reliability and performance, that still ensures competitive selection, can be obtained from the Facilities FCS Department.

The intent of the design procedures just presented is to develop a complete set of contract documents so the contractor will furnish and install sensors, conduit and wire, pneumatic damper and valve operators, and tubing field locations to the FID panels. The contractor installs the FID cabinets and internal components and connects the wiring and pneumatic tubing. Reference Facilities Construction Standard Specification Section 13943, Facilities Control Systems, for the complete set of requirements.

Sandia/NM furnishes the following:

- FID cabinets and all internal components, and instructions on how to terminate the wires and tubing. Plant Control Center personnel install the majority of the internal components
- All required programming and loading at points listed in the I/O summary into the host computer to implement the sequence of operation delineated on the drawings
- Downloading of programs into the FID and assisting the contractor with commissioning of the complete monitoring and controls system for the building.

8.23.2 Pneumatic, Electric, Electronic Controls

The use of pneumatic controls shall be avoided on future projects whenever other types of controls are available to perform satisfactorily and safely.

Thoroughly detail temperature, humidity, pressure change, action, and type of each controller. Where pneumatic systems are used, consider the entire effective range on industrial controllers.

Completely describe the step-by-step sequence of operation for each device in the control system (whether electric, electronic, or pneumatic) on the drawings, rather than in the specifications. Show the pneumatic pressures for both ends of the throttling range that correspond to temperatures on the drawings. In every instance, specify a pressure gauge at each unit of a pneumatic system. No air gauges are required where thermostats are flush-mounted with concealed connecting tubing.

Where FCS does not provide the control function, set up the control system around electronic or direct digital controllers that can be provided by a single supplier, and identify each item of equipment with the current product number. On the mechanical equipment list, show those items with an electrical connection. Provide a device description, range, set point, differential, contact rating, product number, etc., on the equipment list.

Equip pneumatic control systems with an automatic refrigeration air dryer, a compressed air prefilter, and an oil coalescing filter installed in the system's supply line to ensure dry and clean control air. Provide an automatic low-limit bypass to bypass air around the dryer in the event of a freeze-up.

Do not install pneumatic controls outside or in other unheated locations. Use electric actuators wherever control equipment may be exposed to sub-freezing weather.

Designs for building additions should be compatible with the original building system.

Where FCS sensing and control is not utilized, use a combination heating/cooling thermostat in preference to separate heating and cooling thermostats in a given area. Use 7-day programmable auto-changeover thermostats wherever possible.

In addition to detailed wiring diagrams that may appear on the electrical drawings, include a functional diagram on the mechanical drawings for all systems to show the entire sequence and general scheme of operation and all set points. Superimpose the functional diagram on a flow diagram of the heat transfer process.

See Chapter 8.23.1 for Facilities Control Systems requirements. Where FCS does not provide the control function, see Chapter 9.7, Control System Design, for the control drawings required on electrical control systems.

Size control valves with consideration to operate at system pressures and with flow and pressure drop clearly indicated.

Refer to Facilities Construction Standard Specification Section 13943, Facilities Control Systems, for additional information.

8.23.3 Controls for Non-FCS Buildings

Install the following special controls for energy conservation in small-sized buildings (less than 10,000 square feet) that do not merit FCS involvement. If a nearby building has an FCS installed, connect the small size building to the nearby FCS and use the FCS in lieu of the programmable time switch mentioned below.

Equip smaller buildings with a programmable thermostat that provides night temperature setback and disables cooling during unoccupied hours.

Buildings with central systems shall have the following special automatic controls:

- A 7-day programmable time switch with a bypass switch to shut down the following:
  Noncritical exhaust system
  Heating water circulating pump and steam coil
  Supply fans
  Return-relief and noncritical exhaust fans
  Building air conditioning equipment, such as chilled water circulating pumps or air conditioning condensers and compressors
  Domestic hot water circulating pumps
  Outside air dampers (close).

Provide the following to protect the building during extreme outside low temperatures:

- Thermostat located in a sensitive place in the building that will restart the following when the interior temperatures drop below 55°F
  Supply fans, if the building does not have perimeter heating
  Heating water circulating pump and steam coils.

- Time-delay relay for fast warm-up to turn on the following if the building low-temperature thermostat has not reacted. (Provide a bypass switch around the timer.)
  - Supply fans
  - Heating water circulating pumps, steam coil during winter season, or air conditioner and chilled water pump during summer
  - Bypass the hot water reset control from the normal heating schedule.
- Additional features to reinstate the building to normal operating status at the beginning of the work period per the following:
  - Startup of domestic heating water circulating pump
  - Startup of noncritical exhaust fans
  - Opening of dampers to the normal, mixed, and outside control position
  - Restart of the return-relief fans.

8.24 Vibration Isolation and Alarm

8.24.1 Design Conditions

Select rotating equipment to vibration levels measured in any plane on the bearing cap (in the installed and operating condition) in accordance with Construction Standard Specification 15200, Vibration Limits and Control.

Show large supply fans, compressors, utility exhausters, and other rotating and reciprocating equipment mounted on vibration isolating bases incorporating springs, so 90 percent of the lowest disturbing frequency is isolated from the structure. Indicate in the equipment list the type of isolation that is to be supplied. Add special instructions for the equipment manufacturer to provide a coordinated isolation system.

Isolate mechanical equipment that has extremely high noise or vibration levels, including the distribution piping, on springs to minimize the transmission of vibration or noise into the building components and occupied spaces.

Connect an alarm signal to the FCS at the same location where special vibration switches are installed to shut down equipment.

8.24.2 Calculations Required

Provide written evidence of how isolation was selected for equipment installations that produce vibration or noise in usual ranges. Installation of equipment that produces extremely high levels of noise or vibration requires the following calculations:

- Static deflection
- Fundamental natural frequencies of machine mounting system.

8.24.3 General

Provide raised concrete pads isolated from the building structure with elastomer bonded glass fiber material under all major items of equipment, pumps, etc. It is the responsibility of the mechanical designer to transmit this information to the structural designer so it can be shown on the structural drawings.

Make the final attachment of ductwork to fans with inorganic flexible connections. Use weatherproof connections when exposed to the weather. Flame-retardant flexible connections are generally recommended. Use noncombustible connections on piping that contains flammables. Use flexible connections to connect building piping to air compressors (see Chapter 8.15, Compressed-Air System Design).

Connect refrigeration piping to compressors with refrigerant pressure-rated flexible metallic sections, oriented parallel to the crank shaft.

Make final connections of fluid piping to pumps, towers, and other vibrating machinery with suitable flexible connections, such as "Resistoflex" bellows. Provide adequate anchoring of piping next to flexible connections.

Use spring-loaded pipe hangers when necessary to prevent vibration and sound transmission.

Add notes to the description in the equipment list to instruct the vendor of noise or vibration-producing equipment in excess of 5 hp. The vendor shall certify that the equipment and its supporting structures have been balanced statically and dynamically and that they are free from natural frequencies within 30 percent of its operating speeds.

Detail mounting frames where required (for example, roofs). Do not indicate overall dimensions. Relate the size to the equipment being supplied to obtain a coordinated system.

8.25 Sound Control

8.25.1 Design Conditions

Unless otherwise noted in the Design Criteria, establish design goals according to good engineering practice and the ASHRAE Guide and Data Book tables of design goals for sound control.

8.25.2 General

Minimize noise transmission throughout the structure. Establish that noise generated from outdoor equipment will not disturb neighbors or indoor occupants.

Select fans, or other equipment that radiate directly into an occupied area, that are quiet enough to meet ASHRAE noise criteria curves for the occupancy. Select diffusers and grilles with sufficiently low velocity to provide a noise level that meets the ASHRAE noise criteria curve for the occupancy.

Design or select sound attenuating devices as required to meet the ASHRAE noise criteria curve for the occupancy.

8.26 Insulation

8.26.1 Calculations Required

Specify insulation for ducts, piping, and heat-producing equipment where economic operating cost savings will offset the cost of the insulation within its life expectancy. Assume that the life

expectancy of insulation is not more than 20 years for laboratory and administrative applications. Insulation is usually required when the following conditions occur:

- When the heat loss or gain of the ductwork or piping, without insulation, increases the energy requirements of the building.
- When condensation can occur on the surface of the ductwork or piping. This is possible when the ambient dew point temperature is lower than the air or fluid temperature in the duct or pipe.

Calculate the insulation thickness necessary to prevent condensation on piping where domestic cold water or chilled water lines with 65°F or cooler water runs through spaces where the pipe temperature could be below the dew-point. Comply with ASHRAE Standard 90.1.

8.26.2 Insulation Materials

Refer to Facilities Construction Standard Specification Sections 15081, Duct Insulation, and 15083, Pipe and Equipment Insulation.

8.26.3 Insulation–General

In no case specify or accept a combustible-type insulator or duct liner.

8.27 Water Treatment

8.27.1 Open Recirculating Systems

All cooling towers and fluid coolers shall have a water treatment system installed. Install Schedule 80 PVC piping such that a sample line is taken from the tower water supply line, to a conductivity controller, and returned to the tower water return line. Provide chemical injection points downstream of the controller. Check valves shall be installed on either side of these chemical injection points on a vertical section of pipe so as to protect the controller and chemical feed tanks from reverse flow conditions. Minimize the use of pure chemical feed lines, when feasible to do so. The controllers, sensors and injection pumps shall be Sandia/NM furnished and contractor installed. Each system shall have:

- Sized make-up and bleed lines and valves
- Flow meters installed on both the makeup and bleed lines. These shall be pulsing-type flow meters, with an acceptable operating range. Where possible, the flow meters will be tied into the FCS.
- Conductivity controller(s) and associated flow switch(es) installed, but not calibrated.
- Provisions for the injection of biocide and scale/corrosion inhibitor chemicals downstream of controller by providing tie-ins for future installation of chemical feed lines (typically 3/8” or ½” lines).
- Sufficient footprint and wall space for tanks, flow meters, controller(s), and sample line.
- Sample line at controller.

Contact Sandia/NM systems engineer responsible for water treatment for further details of open, recirculating water treatment systems.

8.27.2 Chilled and Hot Water Closed Loops

Make provisions for the periodic injection of corrosion-inhibiting and biocide chemicals on closed loop systems. Install chemical pot feeder with sufficient clearance to pour in 5-gallon drum of chemical. Standard chemical pot feeder shall be stainless steel with a 0.5-micron polypropylene bag filter, operating pressure up to 150 psig, operating temperature up to 200 ^{o}F, 40-gpm maximum flow and 3-psi pressure drop. Feeder shall be piped to the nearest floor drain. Consult Sandia/NM Standard Drawing MP5013STD, "By-Pass Feeder," and the Sandia/NM Systems Engineer responsible for water treatment for further details of closed loop water treatment systems.

8.28 Painting and Pipe Identification

8.28.1 General

Where practical, specify a factory finish for all mechanical equipment. Paint all other mechanical items except in the equipment rooms. See Facilities Construction Standard Specification Section 09900, Painting.

After painting is complete, thoroughly identify all piping with appropriate Brady self-adhesive labels. Ensure that the mechanical contractor understands that he or she is responsible for the accuracy of labeling and the direction of flow.

8.28.2 Underground Utilities

Mark the location of all underground utilities with a continuous identifying tape buried in the pipe trench above the pipe. Refer to Facilities Construction Standard Specification Section 02200, Earthwork. In addition, mount utility marker posts with painted descriptive titles over underground utility lines in remote areas.

For utilities installed in remote locations, specify underground utility markers per Standard Drawing WU5006STD, Utility Markers for Buried Pipe and Cable.

8.29 Test and Balance

The mechanical designer is responsible for determining the extent of Test and Balance that is necessary to prove that systems and equipment are operating as intended. Normally the Test and Balance service is provided by a Test and Balance agency hired by Sandia/NM and working jointly with the construction contractor as specified in Construction Standard Specification 15901 – System Component Checkout and Balance. The designer is responsible for reviewing the final report to determine if the design intent will be achieved and for providing options on how to correct deficiencies.

- End of Chapter -

Chapter 9 - Electrical Design Standards

9.1 Introduction

The primary objective of these guidelines is to achieve consistency and accuracy in electrical facilities engineering design through awareness and standardization. For general requirements see Chapter 1, Introduction to the Facilities Design Standards Manual, and Chapter 2, General Design Standards and Procedures. Because the requirements for each job vary, descriptions for the following items will not be presented in this standard:

- Power master substations
- Power transmission or overhead distribution lines.

Refer to the Electrical section of the Project-Specific Design Criteria for these requirements. For products and construction methods, see the Facilities Construction Standard Specifications.

9.2 Construction Drawings

Refer to the Facilities CADD Standards Manual for specific drawing requirements.
Table 9-1 presents the plans and/or drawings required for a typical electrical job.

Table 9-1. Electrical Construction Drawings

Drawing	Scale	Remarks
Electrical Site Plan	1 inch = 20 feet	
Lightning Protection and Counterpoise Composite Plan	1 inch = 20.0 feet	
Grounding Plan	1 inch = 20.0 feet	
Power: One-Line Diagram	--	
Grounding: One-Line Diagram	--	
Power Plans	¼ inch = 1.0 feet	
Lighting Plans	¼ inch = 1.0 feet	
Special Systems Plans as Required	¼ inch = 1.0 feet	
Grounding Details	--	
Low Voltage Switchgear Elevation and Details	--	
Motor Control Center Details	--	
Miscellaneous Elementary and Wiring Diagrams	--	
Miscellaneous Details: Lightning Protection	--	
Equipment List	--	
Power Duct Plan and Profile (Civil Work Drawing)	1 inch = 50 feet horizontal	
High Voltage Switchgear, Transformer, Metering Pad Details	--	
Primary Electrical System One-Line Diagram	3/4 inch = 1 foot	
Electric Manhole Plan, Details and	--	

Drawing	Scale	Remarks
Section		

Locate all electrical symbols and equipment locations to scale on plan drawings.

9.3 General Design Requirements

9.3.1 General

Resolve code conflicts by using the more stringent applicable portion of conflicting codes unless Sandia/NM grants a written waiver.

- Use the list of standard symbols shown on Standard Drawing E-0006STD, and include the drawing in the construction package.
- Add additional symbols not shown as needed.
- Keep abbreviations to a minimum.
- Use only standard technical abbreviations from the ANSI and the IEEE on all drawings.

9.3.2 Wiring

- Wiring shall be in electrical metallic tubing, wireways, or other approved raceways.
- Connections to building equipment which can be moved by hand for access and servicing shall be connected to building wireways by flexible metal conduit of sufficient length to permit the required movement without disconnecting the wiring.
- Branch circuit conductors shall be minimum 12 AWG and shall be copper, type THHN/THWN unless otherwise noted.
- Control wiring shall be minimum 14 AWG.
- Reduced-size neutrals are prohibited without prior and specific Sandia/NM approval.
- Run equipment-grounding conduct sized per NEC with all power and control circuits over 50 volts.
- Branch circuit wiring to receptacles and lights in a NEMA 1 environment may be a manufactured metal-clad cable assembly such as MC cable. When used, it must be concealed in walls or above accessible ceilings. It may not be used where surface-mounted conduit is required. The minimum conductor size is #12 AWG THHN with ground, with conductor jacket colors matching Sandia's standard voltage/phase colors (See Standard Drawing E-0006STD).

9.3.3 Circuiting

- Home runs for receptacle, power, and lighting may be indicated with an arrowhead, panel/terminal cabinet number, and circuit/terminal block number. This method may be used for branch circuits and terminal loads; all feeders and conduit 2" or larger shall have designed runs designated on the drawings.
- Identify the conduit size and then umber and type of conductors it contains.
- For typical circuits, this information may be listed by general note. For example, "All conductors are 12 AWG THHN/THWN in ½-inch conduit unless otherwise noted".

- Individual circuits between light fixtures and to light switches may be indicated by showing switch letter and circuit number at each fixture.
- Show exterior conduits running to or from a building on the electrical and civil works (exterior utilities) site plans.
- Circuitry shall be overhead; do not run in slab, and avoid under slab when possible.
- Group 120V branch circuitry into multiple ABC sets and share neutral and ground where possible; multiple circuit sets shall originate from adjacent ABC circuit breakers.
- Group circuit homeruns where feasible, derated as required and show on drawings; do not leave this up to the contractor.

9.3.4 Exclusions

- No welding or cutting of structural steel for electrical systems is allowed unless specifically approved by Sandia/NM.
- Busway systems shall not be installed unless specifically approved by Sandia/NM.
- Cable tray systems shall not be used for power cables unless specifically approved by Sandia/NM.
- Underfloor duct systems shall not be installed unless specifically approved by Sandia/NM.

9.3.5 Other Requirements

- Size all junction and pull boxes shown on drawings.
- A mounting detail is not necessary for small devices normally mounted on a wall; a simple statement about the mounting height is sufficient.
- Prepare elevations and details to show the mounting method for all other equipment such as large transformers and large control cabinets.
- Specify that all floor mounted, electrical equipment be installed on a 3½" house keeping pad.
- Indicate all fire barrier penetrations on electrical plan drawings.
- Specify that openings around electrical penetrations through fire-resistance rated walls, partitions, floors and ceilings to be firestopped to maintain the fire-resistance rating.
- Specify the method of sealing openings on the electrical plan drawings, and coordinate all sealants used with the architectural designer.
- In general, equipment specified must meet the energy efficiency requirements per 10 CFR 436, Sub Part A.
- Provide a telecommunication drop at service entrance electrical equipment rooms that are 100 square feet or larger. Provide an additional telecommunications drop adjacent to a Facilities Control System cabinet (preferably in the equipment room). See Chapter 10, Telecommunications Design Standards, for telecommunications details.
- Make adjustments to manufacturer's altitude rating as required for the altitude of 5,500 feet at the Sandia/NM.
- Provide a separate and local disconnecting means for mechanical equipment requiring line electrical power. The disconnecting means shall be separate from the equipment but may be mounted on it, and shall be operable without any disassembly or opening of the equipment access covers. It shall have provisions for lockout-tagout (LOTO), and shall be rated for the service and location including any motors in the equipment. In addition

to those disconnecting means required by NFPA 70, Sandia's requirement includes, but is not limited to, fan-coil units, variable-air-volume boxes, lighting fixtures, damper and valve actuators, small exhaust fans, and the like. The branch-circuit circuit breaker servicing the assembly shall not be used to satisfy this requirement. Coordinate the requirements for this disconnect with the assigned Sandia electrical systems engineer.

- Install electrical sources of 50 volts or greater for a TEC in a separate NEMA 1 enclosure with a line side disconnect.
- Install a maximum of five (5) Terminal Equipment Controllers per disconnect or 24volt power circuit. Reference FCS drawing MI5001STD.
- Motors rated below 1 HP may use a general duty safety switch as a disconnecting means.

9.4 Lighting Systems Design

9.4.1 Interior Lighting Systems Design

Specifications:

- Construction Standard Specification Section 16501, Fluorescent Luminaires
- Construction Standard Specification Section 16514, Electrical High Intensity (HID) Luminaires and Lamps

Standard Drawings:

N/A

System Drawings:

- Locate lighting fixtures on reflected ceiling plans (EL - series drawings)

Design Philosophy:

This section strives to provide adequate, comfortable, and reliable indoor illumination levels for the tasks to be performed without over-lighting the workspace and wasting energy, and in a manner that can be serviced regularly without extraordinary maintenance procedures or equipment.

The preferred indoor general lighting fixture is the straight, 3500°K 48 inch F32T8 lamp as described in Construction Standard Specification 16501, Fluorescent Luminaires. The 24 inch F17T8 lamp is to be used in 2x2 fixtures. When ceiling height and/or equipment clearances dictate, certain high-output and MHID fixtures may be authorized indoors, but only:

- In fixtures where the lamp is shielded from direct view, or
- In high bays where the lamp is some distance from the observer, and
- With specific approval of the Sandia Lighting Committee.

If the lighted area contains small rooms enclosed by fixed partitions and/or is occupied by fixed structures or equipment, follow a nonsymmetrical pattern according to the Illuminating Engineering Society of North America (IESNA) Lighting Handbook, using the recommended

practice for office lighting. If the lighted area is a large bay and a suggested layout is not present in the Electrical Design Criteria, use a modular system so a bay or sectional area can be cut into equal sections without disturbing the fixture pattern.

Use natural or daylighting as much as possible, both for energy management and for architectural esthetics. Provide lighting controls that react to the presence of sufficient daylight contribution to the workspace. Take advantage of task lighting over specified work stations and of daylighting in spaces with skylights or exterior windows. Aggressively design energy management and lighting controls to sense occupancy, time of day, ambient conditions, master controller inputs, or other condition such that energy is conserved and maintenance intervals lengthened when full lighting is not needed. Realize that building residents will conserve lighting in areas for which they are personally responsible, but may not do so in common spaces No space is too insignificant for occupancy sensors or other automatic lighting controls.

Maintenance of fixtures, such as cleaning and replacing lamps and ballasts, is one of the most important design considerations and can override architectural considerations when life cycle cost is considered. Do not locate fixtures where they cannot be safely reached by ladders or lamp snatcher poles. Do not permit other disciplines to occupy space below the fixture mounting planes. Ensure that fixtures are placed in areas that will not conflict with air diffuser patterns, sprinkler heads, and other utilities above the ceilings. Coordinate with Mechanical if heat-removal fixtures are anticipated. Do not specify exotic or expensive lamps and components when standard equipment can be used without sacrificing adequate performance. If special access or handling equipment is needed to service luminaires, ensure this is specified and provided as part of the project design. Proactively determine the programmatic use of the space, and do not locate fixtures where later installation of programmatic equipment will block fixture access. If this cannot be avoided or fully anticipated during the design phase, provide alternative access such as catwalks.

Present or describe a fixture mounting detail for every fixture, using standard drawing details wherever possible. In areas that may be subject to vibration (for example, equipment rooms and rooms near large motors), evaluate the need for a suitable adhesive for all nuts and screwed fittings involved in the fixture mounting. Proper seismic bracing shall be supplied for all fixture types. For lay-in fixtures connected by flexible conduit, the use of Type BX, AC, or MC cable is permitted in lieu of flexible conduit and separate conductors, except that the cable assembly shall have an integral, insulated green ground and that the circuit's wire gauge shall not be reduced.

Where night lights are required, or where inverter-powered emergency fixtures are part of the general illumination layout, connect these lights to the inverter's normally-on output. Where possible architecturally, provide dedicated emergency fixtures such that they are not required as part of the general illumination and connect these lights to the inverter's normally-off output. Be sure that the sum of the power requirements for the normally-on and -off circuits do not exceed the inverter's rating. Identify all inverter-powered fixtures with a Sandia-furnished label visible from the floor.

As noted in chapter 9.15, inverters are typically Sandia Furnished Materials and are placed into operation by Sandia. Specify that all final connections to the inverter shall be made with flexible conduit. Install a dual-channel digital communication control circuit from each inverter to the

nearest FID cabinet. The cables shall be two Belden 88442-002 with red jacket. The final connections at the FID cabinet will be completed by Sandia/NM. Refer to chapter 9.6.10 for blue circuit connection requirements to emergency light fixtures.

Self-ballasted compact fluorescent (CF) lamps of 17 to 26 watts may be used in fixtures that normally would use an A-19 incandescent lamp, base up. Separately-ballasted CF lamps of 9 to 26 watts may be used in downlights, sconces, bollards, pathway markers, and similar accent fixtures where the mounting provisions permit ready access to both the lamp and the ballast.

When it is desired to provide two discrete illumination levels from a 3- or 4-lamp fluorescent fixture, the use of Advance VEL-4P32-2LS ballast and one switch is preferred in lieu of two ballasts and two switched conductors. When it is desired to provide a continuously variable illumination range, use in-line dimmers and ballasts where the circuit to be dimmed can be held to 1000 watts or fewer. Where this is not practicable, such as theater-style conference rooms, use 0-10 volt ballasts and master dimming controllers. Apply a maintenance warning label if the controller's 10v power is provided from other than the main lighting circuit(s) being dimmed.

Required Performance and Features:

- Provide these average illumination levels in the spaces shown, measured at the work surface with all fixtures at full brightness, 15% variance permissible:
  20 foot-candles (fc) in halls at floor level, with 1 fc for night emergency egress
  30 fc at floor level in occupied warehouses, dropping to 10 fc when unoccupied, except that any requirement for vertical illumination in the design criteria takes precedence over this general requirement
  30 fc in conference rooms, lobbies, and informal meeting centers
  35 fc in small offices with indirect lighting and furniture-mounted task lighting, but measured with the task lighting off
  45 fc in general offices, maintain 3:1 ratio between general and task lighting
  60 fc in light laboratories
- Allow for sunlight contribution in windowed offices, but do not automatically turn all lights completely off in an occupied sunlit office.
- Occupancy sensor time delay for fluorescent lights shall be 30 minutes to 45 minutes so as to reduce lamp ignition events.
- Design maximum power consumption to not exceed these levels, excluding special-purpose rooms and offices for the visually handicapped:
  1.7 watts/square foot for light laboratories
  1.3 watts/square foot for general offices
  1.0 watts/square foot for industrial high bays
  1.0 watts/square foot for storage areas, conference rooms, and low bays
  0.6 watts/square foot for corridors and stairwells
- Color rendition index (CRI) for general interior lighting shall be 75% or better.

Prohibited Features and Equipment:

- Incandescent lamps and fixtures, except for HID restrike units, low-voltage MR-type fixtures used for display highlighting, or where an incandescent spectrum is specifically required by the Design Criteria
- F96T12, F96T12HO, F96T12VHO, F40T12, F34T12, and F54T5HO lamps and fixtures
- T12U6 or U8, T8U3, and circular fluorescent lamps and fixtures
- Compact fluorescent lamps over 26 watts unless the fixture provides adequate cooling
- Downlights with CFs mounted horizontally high in the can close to the reflector
- Downlights or other fixtures with ballasts not accessible from the lamp opening, when used in a hard ceiling
- Fixtures where the lamps are very close together and luminaire efficiency is thereby reduced, unless specifically required by the Design Criteria
- Fixtures with specular eggcrate grids (use low-iridescent diffuse silver models)
- Preheat magnetic ballasts
- Rapid-start or program-start ballasts, unless specifically required by the Design Criteria
- Any rapid-start ballast which fails to turn off heater power after lamp ignition
- High-pressure sodium (HPS) or other "non-white" lighting inside a regularly occupied building, unless specifically required by the Design Criteria
- Self-powered battery life safety fixtures, except where an inverter is not available

9.4.2 Exterior Lighting Systems Design

Specifications:

- Construction Standard Specification, 16521, Exterior Lighting Units

Standard Drawings:

- Standard Drawing WJ5010STD, Exterior Lighting Details
- Standard Drawing WJ6001STD, Exterior Lighting Equipment Schedule

System Drawings:

- Locate non-building mounted fixtures on Civil Works (exterior utilities) site plans (WJ – series drawings)

Local Regulations and Requirements:

- New Mexico Statute 74-12-1, The Night Sky Protection Act
- Albuquerque (NM) Ordinance 14-16-3-9, Area Lighting Regulations

Design shall consider HPS or MHID "shoebox" sharp cutoff light fixtures on round, steel, tapered poles, (pole height and lamp wattage determined by the size of the area to be illuminated), that meet the American Association of State Highway and Transportation Officials standards. Exterior lighting design also must follow the provisions of the New Mexico "Night Sky Protection Act," which became effective in January 2000.

In general, exterior building lighting should be switched by photocell with an override switch accessible to qualified maintenance personnel. The preferred fixture for exterior doors and walkway illumination is the 50-watt HPS wall-pack with lamp shield, polycarbonate lens, and a body color coordinated with the building's color scheme. Refer to Facilities Construction Standard Specification 16521, Exterior Lighting Units, for details.

Coordinate exterior lighting and pole-mounted lighting with the Facilities Electrical Systems Engineering Department. If applicable, the Safeguards and Security Department will have additional requirements for minimum illumination levels and for maximum illumination variance between fixtures as may be needed for intruder assessments. Technical Area I perimeter security lighting shall be 277v and connected to one of the perimeter lighting circuits, PGTL-1 and PGTL-2, unless voltage drop calculations prohibit.

A photoelectric controller and contactor are normally used for security systems in remote areas and for fixtures not connected to PGTL-1 or -2. Provide a maintenance hand-off-auto switch, in a NEMA 3R enclosure near the area gate.

Provide these average illumination levels in the areas shown, measured at grade with all fixtures at full brightness, zero sky contribution, 15% variance permissible:

- 5 fc at building entrances, with 1 fc for night emergency egress
- 2 fc at gates and perimeter fences where security assessment is an issue; maintain 4:1 ratio between maxima and minima
- 1 fc in parking lots, maintain 4:1 ratio between maxima and minima
- ¼ fc along illuminated roadways, with 2 fc at major intersections

9.5 Receptacle System Design

Specifications:

- Construction Standard Specification Section 16001, Electrical Work

Standard Drawings:

- E-0006STD, Electrical Standard Symbol List/General Notes

System Drawings:

- Locate on power plan ("EP" - series drawings)

Design the receptacle system per the following minimum requirements:

- Outlets are to be wired vertically in and on walls; do not run circuits horizontally within walls; avoid running circuits horizontally on the outside of walls
- Flush mount outlets in areas such as lobbies, conference rooms, user hallways and office spaces.
- Surface mount outlets in areas including user labs, manufacturing spaces, equipment chases and electrical/mechanical rooms.

- Provide dedicated outlets for janitorial equipment in hallways and aisles maximum 50 feet apart; mount at 36 inches above the finished floor, and segregate from other receptacles.
- Provide general-purpose outlets in electric and mechanical rooms; outlets shall be Ground Fault Circuit Interrupter (GFCI) protected.
- Provide general-purpose outlets outside each external door; outlets shall be weatherproof and GFCI protected.
- Provide rooftop maintenance outlets per NEC; outlets shall be weatherproof and GFCI protected.
- GFCI protection is required on all 120-volt, 15 and 20 amp receptacles located within 6 ft of sinks, shower heads, eyewash stations and outside doors. No outlet is allowed within 3 feet of the vertical axis of shower heads or eye wash stations.

Additional Considerations:

- In buildings where electric personnel vehicles (GEM Carts) are assigned, provide one dedicated 120 volt 20 amp GFCI-protected simplex receptacle per cart station on the exterior of the building at the cart parking location(s). Provide a weather cover such that the receptacle meets NEMA 3R standards with the cart charger cord plugged in. Carts will draw 8-13 amps at maximum charge rate.
- Where the building will have wall-mounted television sets connected to the Sandia Video Network, provide a duplex receptacle high on the wall (96"AFF nominal) at the television's location. This need not be a dedicated receptacle. The duplex receptacle is required for the television and for its fiber optics translator.
- Where the building will have wall-mounted ToneAlert® radio paging devices, provide a simplex receptacle high on the wall (72" to 96"AFF nominal) at the devices' locations. This need not be on a dedicated circuit. If the building is to have a central public address (PA) system, consider locating a single ToneAlert® device at the PA chassis and connecting its output through the PA system as an economy measure. Note that the ToneAlert® devices themselves shall be mounted nominally at 72" AFF such that their controls are within reach.

9.6 Low Voltage Power Systems Design (<600 volts)

9.6.1 General

This section covers the general power requirements for low voltage systems consisting of systems less than 600 volts.

9.6.2 Metering

Specifications:

N/A

Standard Drawings:

- EI6004STD (previously 105732/01), Metering Equipment List
- EI7011STD (previously 105733/E01), Metering Connection Point Wiring Diagram

- EI5001STD (previously 105731/E01), Metering Circuit Monitor Enclosure and Details

System Drawings:

- Show Current Transformer (CT), Potential Transformer (PT), and meter connections, also indicate CT and PT ratios on one-line diagrams.
- For indoor installation locate meter, communication circuit connections points and termination points on power plans.
- For outdoor installations, locate meter, communication circuit connections and termination points on Civil Works (exterior utilities) plans.
- For metering details specific to the building or facility, place on EI series drawings.

Electric metering will be provided at all building service entrances, and at disconnecting means downstream of the service entrances, as necessary to separately meter building and process loads. General requirements for electric service entrance metering are detailed in Chapter 2.8.6, Energy Service Meters.

- When metering at switchboards/switchgear and panelboards, the meter(s) shall, where feasible, be supplied by the original equipment manufacturer and installed in the equipment, as specified below. For other metering locations or equipment, the meter location and enclosure will be as specified by Sandia/NM.
- The Square D PowerLogic™ CM3250 circuit monitor will be specified for all new metering installations, as well as for retrofitting purposes, when an existing CM2000-series meter is to be replaced.
- If the CM3250 is specified as part of a new installation, the following equipment will be required:
  - CM3250 Meter (includes standard mounting bracket)
  - CMDVF VF Display w/OCI port (includes 12-foot cable)
  - CM3LA Mounting adapter (may replace standard mounting bracket, depending on where meter will be located in equipment)
  - MCTAS-485 Terminator (one required per daisy chain)
- If the CM3250 will be retrofitted into an existing CM2000-series meter opening, the following equipment will be required:
  - CM3250 Meter (includes standard mounting bracket)
  - CMDVF VF Display w/OCI port (includes 12-foot cable)
  - CM3MA Mounting adapter kit (consists of a blank mounting panel for VF display, and CM3LA mounting adapter)
  - MCTAS-485 Terminator (one required per daisy chain)
- For low-voltage (120/208V and 277/480V) service entrance installations, a 4-wire, wye-connected, 3-PT, 3-CT metering configuration will be used. On medium-voltage (>600V) systems, a 3-wire, delta-connected, 2-PT, 2-CT configuration will be used. Reference the manufacturer's installation manual for detailed connection and other information pertinent to the CM3250.
- The installation will include properly sized CTs, CT shorting blocks, PT/VT fuse blocks, and other standard hardware and wiring necessary to install the meter per the manufacturer's recommendations, and as constrained by this document.

- For CM3250 installations of 600V or less, no PTs are required for voltage conversion. When required, PTs will be selected to transform the line-neutral (4-wire installations) or line-line (3-wire installations) primary voltage to 120V. The voltage or PT primary connection will be made on the line side of the service entrance disconnect.
- Metering CTs should be sized for the full load current of the metered transformer, or the bus rating of the metered equipment, whichever is larger. Select CTs to reduce the rated primary current to 5 amps. CTs may be located on either side of the service entrance disconnect.
- A RS-485 communications circuit or other dataway specified by the Systems Engineer will be extended from the meter(s) to the nearest telephone terminal cabinet or Intermediate Distribution Room (IDR). Where several meters are being installed in the same facility, meters will be interconnected locally via an RS-485 data circuit, and a single communications home run will be extended from the telephone terminal cabinet or IDR to the nearest meter. The communications circuit will be terminated per the manufacturer's specifications.

9.6.3 Panelboards

Specifications:

- Construction Standard Specification Section 16440 "Electrical Panelboards"

Standard Drawings:

N/A

System Drawings:

- Locate on power plan (EP – series drawings).
- Provide completed panel schedules using Sandia's current Microsoft Excel template.

Panelboards shall be as follows:

- Locate indoors where possible. Avoid outdoor or rooftop locations.
- Locate in hallways and dedicated electrical rooms or closets where possible; avoid user spaces.
- Flush-mount only in areas such as user hallways and office spaces. When flush-mounted, provide spare conduits, skirting or other provisions to facilitate future modifications.
- Surface-mount in all other areas including user labs, manufacturing spaces, equipment chases and electrical or mechanical rooms.
- Panelboards located in areas accessible to users shall be designed to be less than 10,000A available fault duty current.
- Panelboards with greater than 10,000A available fault duty current shall be located in electrical rooms/closets or mechanical/electrical spaces accessible only to qualified personnel.

- Multiple section panels are not permitted. Where it is necessary to have more than 42 circuits in a lighting or appliance panelboard in the same location, use additional, separately-circuited panelboards.
- Typically avoid subfeed or dual-feed lugs.
- Avoid individually-mounted subfeed circuit breakers.
- Main circuit breakers are to be sized according to NEC 450.3 (A) for any location. If a larger breaker is installed, then the appropriate trip plug must be installed as well. It is not permitted for the trip settings to be dialed-down to meet the intent of this Section.

Oversize neutrals only when required per harmonic analysis. See Chapter 9.13.7 for Harmonic Analysis Calculations guidelines.

9.6.4 Low Voltage Switchgear/Switchboards

Specifications:

- Provide a Construction Special Specification for each new installation.

Standard Drawings:

N/A

System Drawings:

- Locate on power plan (EP – series drawings).
- Detail on one-line diagram, include all loads, circuit numbering and spaces.
- Provide elevation showing all circuit breaker locations and circuit numbering.
- Provide additional details, schedules or other information on drawings as necessary for construction.

Low Voltage Switchgear/Switchboards shall be as follows:

- Locate indoors where possible. Avoid outdoor locations.
- Locate in dedicated electrical rooms accessible only to qualified personnel.
- Front accessible where possible, except service entrance equipment.
- For service entrance equipment, provide rear access when possible.
- Copper main bus; 100 percent capacity full length.
- Copper neutral bus, if required; 100 percent capacity full length.
- Copper ground bus; full length.
- Main and feeder circuit breakers arranged for compression connectors.
- All circuit breakers shall be NEMA construction.
- All circuit breakers shall have provisions for lockout/tagout (LOTO).
- All circuit breakers shall include electronic interchangeable trip with adjustable LTPU, LTD, STPU, STD and INST functions. When required, provide integral GFPU and GFD functions.
- When ground fault is required, provide two level protection (main and feeders).

- Provide service entrance label when required.
- Provide minimum 25 percent spare capacity.
- Provide minimum 1-spare circuit breaker of each frame size (excluding main) used.
- Provide future bus extension and dedicated space for at least one future section.
- Provide integral Square D Power Logic metering located on the line side of the main (see Chapter 9.6.2 for more information on metering).
- Provide integral Surge Protection Device (SPD) to meet requirements of NFPA 780, when required.
- Where draw-out circuit breakers are specified, provide manufacturer's overhead lifting device suitable for all circuit breaker sizes and locations.
- Provide manufacturer's test kit for all circuit breaker types and functions used.
- All circuit breakers larger than 200 amps shall be tested. See Standard Construction Specification 16442, Part 3.05E for an example of the requirements.
- Main circuit breakers are to be sized according to NEC 450.3 (A) for any location. If a larger breaker is installed, then the appropriate trip plug must be installed. It is not permitted for the trip settings to be dialed-down to meet the intent of this article.

Oversize neutrals only when required per harmonic analysis. See Chapter 9.13.7 for Harmonic Analysis Calculations guidelines.

9.6.5 One-Line Power Diagram

Specifications:

N/A

Standard Drawings:

- E-0006STD, Electrical Standard Symbol List/General Notes
- E-0007STD, Electrical One-Line/Wiring Diagram Symbols

System Drawings:

- Develop or add to one-line diagram drawing (EP – series drawings) as noted below.

Starting at the top of the drawing with the building transformers(s), show all pertinent electrical equipment down to the panelboard level. This includes switchboard/switchgear, panelboards, MCCs, generators, transfer switches, uninterruptible power supplies, Inverter systems, etc.

For transformers, note kVA size, primary and secondary voltages, phasing (building service entrance only), and impedance. Show the Distribution Switchboard/Switchgear in "expanded" form. The drawing should detail Main breaker, Tie breaker, Feeder breakers, Spare breakers, CT's, PT's, and meter. Note Switchboard rated amperage, voltage, and short circuit capability. Include frame and trip size of all breakers in the gear.

Note service entrance, feeder wire and conduit sizes.

For larger buildings, additional one-line diagram drawings may be required. If the building utilizes Motor Control Centers (MCCs), separate one-lines may be required. When MCCs are necessary, provide them in "expanded" form. Drawings should be called MCC One-Line Diagram and be numbered sequentially with the Main One-Line. Indicate starter/breaker sizes, bus tap sizes, wire, and conduit size ending with each motor or other load. If the building has a large Standby Power System or Blue System, provide in "expanded" One-Line of this system also.

In general, use the following guidelines:

- If a Building transformer is not associated directly with the building, start the One-Line with the largest distribution panelboard.
- If all details can be shown on one sheet, it is allowable to use "expanded" details on all necessary equipment.
- Place highest voltage lines at the top of the drawing with successively lower voltages placed downward.
- Use standard symbols listed on Standard Drawing E-0007STD and in ANSI standards.
- All "expanded" gear shall be shown with a dashed outline. All singular items shall be shown with solid outlines
- Draw circuits in the most direct and logical sequence. Draw lines between symbols either vertically or horizontally with a minimum of line crossing.
- Note panelboards and major equipment locations (Column D4, NE Equipment Room, etc.) Try to group equipment on drawings by physical locations.
- To avoid clutter, do not put specialty symbols and construction notes on the One-Line. Grounding, controls, metering and miscellaneous details should all be on separate drawings.

9.6.6 Low Voltage Dry Type Transformers

Specifications:

- Provide Construction Special Specification, or specify on drawings and Equipment Lists.

Standard Drawings:

N/A

System Drawings:

- Locate on power plan (EP – series drawings).
- Provide additional elevation or mounting details as required for construction.

Low Voltage Dry Type Transformers shall be as follows:

- Locate indoors where possible; avoid outdoor locations.
- Energy efficient type; meet NEMA TP-1.
- Specify transformer to include +2/-4 at 2.5 percent taps.

- Transformers located in areas accessible to users shall be designed to produce less than 10,000A available short circuit current.
- Transformers allowing more than 10,000A available short circuit current shall be located in electrical rooms/closets or mechanical/electrical spaces accessible only to qualified personnel.

The sizing of step down or step up dry type transformers shall take into consideration the current or expected normal and harmonic loading. The decision to use "K" transformers will be based on harmonic analyses of the connected and forecast load. See Chapter 9.13.7 for Harmonic Analysis Calculations guidelines.

9.6.7 Motors

Specifications:

- Construction Standard Specification Section 16001, Electrical Work
- Construction Standard Specification Section 16269, Variable Frequency Controllers

Standard Drawings:

- E-0006STD, Electrical Standard Symbol List/General Notes

System Drawings:

- Locate on power plan (EP – series drawings)

Motors that are controlled by across the line motor starters and are 25 HP or larger shall include power factor correction capacitors at the motor starter in order to achieve 95 percent power factor. VFC controlled motors are excluded from the power factor correction requirement.

Specify motors per Chapter 8.5.2.

See Facilities Construction Standard Specifications Sections 16001, Electrical Work, and 16269, Variable Frequency Controllers, for additional motor requirements.

9.6.8 Motor Control Centers

Specifications:

- Provide a Construction Special Specification for each new installation.

Standard Drawings:

N/A

System Drawings:

- Locate on power plan (EP – series drawings).
- Detail on one-line diagram, include all loads, circuit numbering and spaces.

- Provide elevation showing all starter locations and circuit numbering.
- Provide additional details, schedules or other information on drawings as necessary for construction.

Motor Control Centers (MCCs) shall be as follows:

- Locate them indoors where possible; avoid outdoor locations.
- Locate them in dedicated electrical rooms accessible only to qualified personnel.
- Use front accessible where possible.
- Use copper main bus; 100 percent capacity full length, minimum 600A.
- Use copper neutral bus, if required; 100 percent capacity full length.
- Use copper ground bus; full length.
- Wire MCCs for NEMA Class I, Type B.
- Starters shall be combination type with motor circuit protector, contactor and LOTO provisions.
- Circuit protectors, contactors, overload blocks and all accessories shall be NEMA construction.
- Starters shall include overload reset button, red and green, LED type pilot lights - red for “run” mode and green for “stop”.
- Provide HOA in cover; minimum 2-N/O and 2-N/C auxiliary contacts and individual control power transformer (CPT) if above 150V to ground.
- CPT, if required, shall be sized for 100 VA extra capacity and include 2-primary and 1-secondary fuses for 120V control.
- Avoid circuit breakers only in MCCs; instead, feed from a power panel.
- Do not mount panelboards or associated transformers in MCCs.
- Do not mount VFCs in MCCs; VFCs shall be individually mounted at controlled motor.
- Provide future bus extension and dedicated space for at least one future section.
- Provide minimum 25 percent spare amperage capacity.
- Typically, provide 10 percent spare buckets for each size provided.

9.6.9 Individual Motor Starters

Specifications:

- Construction Standard Specification Section 16269, Variable Frequency Controllers
- For non VFC starters, provide specifications on drawings

Standard Drawings:

N/A

System Drawings:

- Locate on power plan (EP – series drawings)

Individual Motor Starters (non-VFC) shall be as follows:

- Locate indoors where possible; avoid outdoor locations.
- Starters shall be combination type with motor circuit protector, contactor and LOTO provisions.
- Circuit protectors, contactors, overload blocks and all accessories shall be NEMA construction.
- Starters shall include overload reset button, red and green, LED type pilot lights - red for "run" mode and green for "stop".
- Provide HOA in cover; minimum 2-N/O and 2-N/C auxiliary contacts and individual control power transformer (CPT) if above 150V to ground.
- CPT, if required, shall be sized for 100 VA extra capacity and include 2-primary and 1-secondary fuses for 120V control.
- The use of "intelligent" starters or other control devices which operate by a remote or on-board microprocessor shall be plainly identified, along with provision for communications dataways necessary to support the proper programming, operation, and monitoring of the device by the FCS and/or process control equipment.

Variable Frequency Controllers shall be as follows:

- Locate indoors where possible; avoid outdoor locations.
- Typically VFCs will only be installed when requested by the Mechanical Engineer.
- Contrary to previous requirements, a manual by-pass is not typically required on a VFC. A by-pass should only be specified after discussing the requirements with the Mechanical Engineer.
- Do not install VFCs closer than five feet to a FID cabinet for heat protection.
- The use of "intelligent" VFCs which operate by a remote or on-board microprocessor shall be plainly identified, along with provision for communications dataways necessary to support the proper programming, operation, and monitoring of the device by the FCS and/or process control equipment. This addresses control and monitor features separate from the simpler 4-20ma or pneumatic circuit which commands a VFC's motor speed.
- See Construction Standard Specification 16269, "Variable Frequency Controllers", for VFC requirements.

9.6.10 Blue (Maintenance) Circuit System

Specifications:

N/A

Standard Drawings:

N/A

System Drawings:

- Locate on power plan (EP – series drawings)
- Detail on one-line diagram

Provide a blue circuit in 1) multiple story structures, unless otherwise noted, 2) in Sensitive Compartmented Information Facility (SCIF) areas, and 3) where specified in the design criteria. The blue circuit is a dedicated receptacle and lighting circuit utilized by facilities maintenance personnel during scheduled preventive maintenance power outages and during unscheduled outages to provide lighting and receptacle power in key areas. The blue circuit reduces the setup time to provide temporary lighting and power for tools to perform maintenance activities.

Provide one duplex receptacle in each electrical room, maintenance area, penthouse, equipment chase, hallway or similar area containing panelboards, transformers, or VFCs. Provide one duplex receptacle inside each SCIF areas or vault-type room containing panelboards, transformers, or VFCs. In large areas receptacles shall be spaced a maximum of 50 feet apart. Provide blue colored receptacles and paint associated outlet boxes blue; do not paint receptacles.

Provide lighting powered by the blue circuit in each stairwell, electrical room, maintenance area, penthouse, equipment chase, hallway or similar area (if not provided by an emergency lighting inverter circuit). Paint or otherwise mark lighting fixture as being on the blue circuit system. Provide a two-pole, double throw manual transfer switch on the load side of each inverter to transfer the emergency lighting power source from the inverter to the generator connected to the blue circuit.

A portable external generator provides power to the blue circuit. Provide a 100A, 208Y/120V, 3-phase, 5-wire, pin and sleeve receptacle located on the outside of the building in a location easily accessible by a vehicle for connection to the generator. Provide a 100A, 208Y/120V, 3-phase, 4-wire panelboard located in the building main electrical equipment room. Paint the panelboard blue to identify panel as being part of blue circuit system. Completely isolate the blue circuit from regular and emergency/standby power circuits. The blue circuit shall not share raceway systems with other electrical systems within the building.

9.7 Control System Design

Specifications:

- Construction Standard Specification Section 16001, Electrical Work

Standard Drawings:

- E-0006STD, Electrical Standard Symbol List/General Notes
- E-0007STD, Electrical One-Line/Wiring Diagram Symbols

System Drawings:

- Show on control (EI or MI – series drawings) or power plans (EP –series drawings) as detailed in this section.

9.7.1 General

Control systems include, but not limited to:

- Laser Interlock
- Facilities Control Systems (FCS)
- Motor control other than HVAC controlled by FCS

For interior lighting controls see Chapter 9.4.1, Interior Lighting Systems Design.

9.7.2 HVAC and Facilities Control Systems

HVAC controls are a joint responsibility between the Electrical and Mechanical designers:

- Prepare elementary diagrams per Chapter 9.7.3.
- Refer to Chapter 8.22.2 for FCS details.
- Coordinate electrical equipment noted in the mechanical plans.

9.7.3 Elementary Control Diagrams

Use a ladder-type layout when preparing elementary control diagrams. Simple power wiring and control circuits (for example, those that use only one simple control switch or a normal light switch) are exempt from these requirements.

9.7.4 Sequence of Operations

On simple control systems, the sequence of operations shown on the mechanical drawings will suffice if the elementary control diagram is properly cross-referenced.

Always present a sequence of operations on the electrical drawings for other than simple control systems and for control systems involving only electrical apparatus.

Begin the sequence with the system turned off, carry it through each operational step, and explain the operation of each component throughout its normal operating conditions

9.7.5 Symbols

Use the symbols shown on electrical standard drawings E-0006STD and E-0007STD for elementary diagrams. If components are required that are not included on this drawing, use symbols included in ANSI Y32.2, Graphic Symbols for Electrical and Electronics Diagrams.

9.7.6 Control Wiring Conduit Layout–All Systems

If possible, show control plans on power plan drawings. If not workable, create a separate set of control plans.

9.7.7 Laser Interlock Systems

Contact the laser safety officer in the ES&H Customer Support Teams, department 03127, for the latest laser safety requirements.

9.8 Lightning Protection Systems Design

Specifications:

- Construction Standard Specification Section 13100, Lightning Protection
- Construction Standard Specification Section 16289, Surge Protection Devices

Standard Drawings:

N/A

System Drawings:

- Show components on Lightning Protection and Counterpoise Composite Plan.
- Details as required.
- Show lightning protection system connection to the building counterpoise system.
- Show lightning protection and ground systems and details on ES –series drawings.

Lightning protection systems will be provided when directed by the Design Criteria or the Facilities Fire Protection Engineer and Electrical System Engineer.

Lightning protection systems shall conform to UL Standard UL 96A requirements and NFPA 780, Installation of Lightning Protection Systems. All structures with lightning protection systems will require a UL Letter of Findings. Note on the drawings which certification is required (UL Letter of Findings, or No Certification Required).

For structures having lightning protection but where the A/E is directed not to install surge protection devices in the electrical service entrance equipment, the A/E shall modify the Lightning Protection Specification 13100 by deleting section 1.01.F.3 and labeling the document as a special specification.

9.9 Building Grounding System Design

Specifications:

- Construction Standard Specification Section 13100, Lightning Protection
- Construction Standard Specification Section 16001, Electrical Work

Standard Drawings:

- ES7001STD, Grounding One-Line Diagram Guideline
- ES7002STD, Grounding One-Line Diagram Guideline

System Drawings:

- Grounding plans
- Grounding one-line
- Grounding details
- Grounding plans and grounding details to be placed on ES – series drawings

The drawings shall show interconnection of the following:

1. All metal systems of the building such as:
   a. Interior and exterior water system
   b. Metal ductwork
   c. Building steel
   d. Lightning protection system
   e. Made electrodes, etc.
   f. Building foundation rebar
2. Where in the electrical system bonding will be required (that is, neutral or ground bushing on transformer).
3. Where the electrode system connects into the rest of the grounding system.
4. Any other special requirements for the building grounding system (that is, static or signal grounds).
5. The size of all required grounding conductors (grounding electrode conductor, equipment grounding conductors, main bounding jumpers, etc.).

The design shall take into account that the NEC as a minimum requirement and other factors need to be considered when designing the system, such as 60-Hz grounds, signal grounds, and lengths of grounding conductors to ground.

9.10 Identification and Labeling

Specifications:

- Construction Standard Specification Section 16001, Electrical Work

Standard Drawings:

- E-0006STD, Electrical Standard Symbol List/General Notes
- E-0011STD, Sample Electrical Equipment Schedule
- WP5021STD, Example Feeder Labeling
- WU5006STD, Utility Markers for Buried Pipe and Cable

System Drawings:

- Numerous

9.10.1 General

To ensure a minimum standard of quality, identify devices, fittings, fixtures, and equipment on equipment list drawings with their electrical sizes, ratings, manufacturer, and catalog number. This is not necessary for items such as panelboards where complete specifications are written.

- Identify motor starters on the motor control schedule. Identify all equipment by using standard symbols and equipment schedules. In addition to the items already mentioned, the schedule should include information to help the contractor obtain the equipment and materials intended by the design.

- Specify nameplates on all control items used on the job. Specify each nameplate either on the motor schedule or on the equipment list. Each nameplate identifies the system and the function of that device to the system.

9.10.2 Electrical Equipment Labeling Designations

The labeling for all panelboards, switchboards, motor control centers, and switchgear shall have a consistent nomenclature and circuit designation to provide a basis for systematic identification of components in the field. This requirement shall also apply to control stations, transfer switches, and equipment of communications and auxiliary systems. See the labeling instructions in Attachment 9

9.10.3 Electrical Equipment Labels

Labels shall be required on each unit of equipment, including central or master unit of each system. This includes power, lighting, telecommunications, signal, and alarm systems, unless units are specified with their own-self explanatory identification.

- Refer to Standard Symbols List drawings E-0006STD, Electrical Standard Symbol List/General Notes and E-0011STD, Sample Electrical Equipment Schedule
- Equipment installed as part of a "Blue" circuit shall consist of the following:
  Receptacles shall have the required circuit and panel identification as well as blue colored faceplates.
  Lighting fixtures (typically an industrial type fluorescent fixtures) shall have a blue identifier such as a blue ballast pan cover or a blue adhesive sticker identifying this fixture as being part of the "blue" circuit system.

9.10.4 Wiring Device Identification

On the plan view, identify each device, its corresponding source, and the circuit number accompanying it. For example, in "BBH1-1" the BBH1 represents the panel name, 1 represents the circuit number.

9.10.5 Wiring Device Labeling

Labeling of wiring devices shall comply with CSI MasterSpec 16075-5, Section 3.1-A through D.

9.10.6 Conductor Identification

All conductors shall be identified with the source the conductor is fed from and circuit number information. Refer to CSI MasterSpec 16000-1.

Multiple Power or Lighting Circuits in the same enclosure: Identify each conductor with source, voltage, circuit number, and phase.

9.10.7 Conductor Labeling

Refer to CSI MasterSpec 16000-1.

9.10.8 Conductor Color Coding

Color-Coding of Power-Circuit and Secondary Phase Conductors to be as noted in the panel schedules and on standard drawing E-0006STD, Electrical Standard Symbol List/General Notes.

9.11 Medium and High Voltage Power Systems Design (> 600 volts)

9.11.1 Underground Distribution Systems

Specifications:

- Construction Standard Specification Section 02584, Underground Ducts and Utility Structures
- Construction Standard Specification Section 16124, Medium Voltage Cable
- Construction Standard Specification Section 16310, 15 kV Metal-Enclosed Stand-Up or Pad mounted Switchgear
- Construction Standard Specification Section 16401, Electrical Distribution System, Aerial
- Construction Standard Specification Section 16475, Primary System Safety Requirements

Standard Drawings:

- WP1001STD, Power Manhole Plan and Section
- WP3004STD, Power Manhole Details
- WP3005STD, Power Manhole Construction Details
- WP5004STD, Typical Concrete Encased Duct
- WP5019STD, S&C Switchgear Configuration and Clearance
- WP5020STD, S&C Pad Mount Switchgear Details
- WP5024STD, Duct To Conduit Installation Detail
- WP6010STD, S&C Pad Mount Equipment List and Details
- WP9001STD, Power Manhole Cable Connections

System Drawings:

- Show plan views and equipment pads on Civil Work drawings, Site Utility/Electrical Plan (WP – series drawings).
- Show profiles on Civil Work (Power) drawings.
- Develop or modify Manhole drawings depicting cable routing.
- Include Primary Electrical System one-line diagram (provided by Sandia/NM).

Tech Area I and IV are fed by a looped underground 12.47 kV distribution system. The existing distribution system consists of electrical manholes and duct banks, and S&C padmount switchgear. Facilities Standard Drawings WP1001STD, WP3004STD, WP3005STD, and WP9001STD show manhole, duct bank, and termination details that must be followed in the design of any addition to the existing 12.47 kV distribution system. Facilities Standard Drawings WP5019STD, WP5020STD, and WP6010STD show the S&C details and clearances that shall be followed. The installation of PMH switchgear other than a PMH-5, PMH-10, and PMH-19 requires prior approval by the Facilities Systems Engineer.

Primary electrical service within Tech Area I, II, and IV shall be at 12.47 kV with each looped circuit consisting of 3-#4/0 CU Shielded, EPR type MV-90 or MV-105, 220 mil, 133 percent

insulation, and 1-#2 THWN, 600V ground. Each end of the 12.47 kV circuit within a manhole shall be terminated with a 600 AMP Non-load break T-Splice as shown on Standard Drawing WP9001STD. The integrity of the loop underground configuration shall be maintained by installing at a minimum two 5-inch PVC concrete encased conduit from the nearest electric manhole. Cable management shall be depicted via power manhole drawings, duct bank and switchgear details. Refer to the Facilities CADD Standards manual on procedures for creating new power manhole drawings. Radial feeds to transformers shall be sized in accordance with the maximum ampacity of the transformer.

Tech Area III and V are fed by a looped underground 4.16 kV distribution system. The distribution system consists of primarily one 3-inch or 4-inch duct bank and underground and above ground pull boxes. Standard Drawing WP5004STD shows the duct bank details that shall be followed in the design of duct banks.

Primary electrical service within Tech Area III and V shall be 4.16 kV with the circuit within the loop consisting of 3#2/0 CU Shielded, EPR type MV-90 or MV-105, 115 mil, 133 percent insulation and 1-#4 THWN, 600V ground. The loop underground configuration shall be maintained by installing one 3” or 4” inch PVC concrete encased conduit from the nearest S&C switchgear. Termination from an underground or above ground pull boxes requires prior approval from Sandia/NM.

Secondary service voltage within all Tech Areas shall be 208/120 V wye, 480/277 V wye, 2400V delta, or 4160/2400 V wye. All transformers shall be fused protected via an S&C padmount PMH-19, PMH-5 or stand-up fused switch. Switchgear and transformer clearances and pad dimensions shall be in accordance with Standard drawings WP3003STD, WP4001STD, WP5019STD, and WP5020STD.

No common wall power and telecommunications manhole installations are allowed. It is desirable to maintain a minimum of 15 feet between the center of power and telecommunications manholes both vertically and horizontally in the plan view.

9.11.2 Transformers

Specifications:

- Construction Standard Specification Section 16272, Padmount Transformers

Standard Drawings:

- WP3003STD, Transformer Fire Barrier Wall
- WP4001STD, Plan and Profile For Transformer Pad

System Drawings:

- Show transformer pads on Civil Work drawings, Site Utility/Electrical Plan (WP – series drawings)

Padmount transformers shall be 1500 kVA or below. Outdoor, oil-filled, padmount, transformers are the preferred method for supplying power to buildings. Refer to Facilities Construction Standard Specification Section 16272, Padmount Transformers, for additional requirements. Transformers in distribution substations larger than 1500 kVA are discouraged. More than one transformer will be necessary if capacity requirements exceed 1500 kVA. Padmount oil-filled transformers shall be Sandia/NM furnished.

The use of high voltage dry type transformers shall require the approval of the Facilities System Engineer.

Transformers sizes shall be based on historical Sandia/NM load data that will be provided by the Facilities System Engineer.

The maximum allowable single-phase pole-mount transformer is 50 kVA. The maximum allowable three-phase pole-mount transformer bank is 3-50 kVA. Transformers above 150 kVA shall be the padmount type. Refer to the Facilities System Engineer on installation requirements. Primary voltages above 15,000 V are considered special and require special designs.

The decision to use "K" transformers will be based on a harmonic analysis. See Chapter 9.13.7 for Harmonic Analysis Calculations guidelines.

The maximum rating or setting of Overcurrent Protection Devices for transformers over 600V shall comply with the NEC, Article 450.3(a), Any Location.

Transformers shall be located and fire protected in accordance to Standard Drawing WP3003STD.

9.12 Standby and Emergency Power Systems

Specifications:

N/A

Standard Drawings:

N/A

System Drawings:

- Locate building generators on power plans (EP – series drawings) or on the electrical site plan (ES or WP – series drawings).
- Prepare detail drawings as needed for construction.
- Locate transfer switches and feeders on power plan.
- Show transfer switches and identify equipment fed from emergency power system on one-line diagram drawing.

Standby power for Tech Area I is typically provided from the Building 862 Standby Generator System. If standby power is determined to be required for a Sandia/NM facility, the design engineer shall conduct a preliminary standby load study for presentation to the Sandia/NM Infrastructure Building Management Team (IBMT) by the assigned Facilities Electrical System Engineer. The IBMT will then determine the appropriate source of standby power for the proposed standby power loads.

Emergency power requirements for a facility are generally provided by the facility in question. However, as in the case with standby power requirements, the design engineer shall conduct a preliminary emergency load study for presentation to the IBMT by the assigned Facilities Electrical System Engineer and the IBMT will determine the appropriate source of emergency power for the proposed facility. Any new standby or emergency generator systems are to have diesel engines as the prime mover and load banks rated for 100 percent of the generator output. Once the decision has been made to install a standby or emergency generator system, contact Department 03121, Environmental Management. Obtaining a permit may take up to 180 days.

Automatic transfer switches for standby and emergency power systems shall be 4 pole switches. For emergency power systems, the automatic transfer switches shall have bypass and isolation switches. For standby power systems, the design engineer shall evaluate and provide recommendations regarding the need for isolation and bypass switches.

9.13 Design Calculations

9.13.1 General

Present all electrical calculations using the guidelines provided in this section. Provide two 8-1/2- by 11-inch, 3-hole-bound reports that contain all electrical calculations, time coordination curves, and protective device settings. Provide one-line diagrams and electronic files with all calculations. At the end of the project, update both reports and electronic files in the same manner as other as-built drawings.

9.13.2 Voltage-Drop Calculations

Prepare a complete set of voltage-drop calculations. When both normal and standby primary feeders serve a facility, provide calculations for both feeders. The preferred calculation method is the SKM Systems Analysis Dapper software program.

The maximum allowable steady state voltage drop shall not exceed 5 percent total for building wiring.

The maximum allowable transient voltage drop shall not exceed 15 percent at the utilization equipment. If a problem is identified, notify the assigned Facilities System Engineer for resolution.

Design the standard voltage profile for regulated power distribution systems to comply with ANSI/IEEE Standard 141-1993 (Red Book) or the latest edition.

Calculate voltage drops for the longest branch circuit to include the drop in feeders, sub-feeders, and transformers back to the first bus with automatic regulation (usually the primary master unit

substation). Do not use a building transformer to correct the secondary voltage drops. Set transformer voltage taps to nominal voltage values under no-load conditions.

Unless loading can actually be predicted, assume the full load for all branch circuits as that limited by the maximum load on the conductors by these standards and/or applicable codes. The power factor for future loading is considered to be the same as when designed.

9.13.3 Short-Circuit Calculations

Prepare a complete set of short-circuit calculations. When both normal and standby primary feeders serve a facility, provide calculations for both. The preferred calculation method is the SKM Systems Analysis Dapper and Captor software program.

Calculations shall consider both three-phase and single-phase to ground fault current on secondary systems. State the base mVA/kVA on the calculations.

Prepare protective device coordination graphs that demonstrate that the protective devices are properly coordinated for interrupting faults. Prepare these graphs for all new or modified primary and secondary systems. Curve plots from the software program Captor are an acceptable alternative.

The design shall include the use of S&C, SMU-20, 12.47 kV, E type, standard speed fuses in 15 kV type S&C padmount or stand-up type switchgear, unless approved otherwise by the Facilities Systems Engineer.

Additionally, present the manufacturer's catalog data on the affected protective devices to show they have adequate fault current interrupting capacity for the available short circuit current.

9.13.4 Wire-Pulling Calculations

When new ducts are required for primary power system (>600V), submit a set of calculations showing the maximum tension placed on the cables during pulling and the maximum allowable tension the cables can withstand. Calculate also, from a pressure standpoint, the force exerted in each elbow or bend during pulling and the radius of each bend. The minimum radius for electrical duct banks is three feet. Calculations shall be performed in both directions with resultants indicating either direction of pull is allowable. Indicate the resultant radii on the plans, plus the pulling instructions that are required as to the method, direction, etc.

9.13.5 Lighting Calculations

Calculate the horizontal illumination levels for each room using the zonal cavity method described in the IESNA Handbook. Similar-sized rooms may be grouped under a single spreadsheet calculation when the illumination level does not vary more than 5%-10% across the group of rooms. When intense point sources such as MHID lights are used for indoor lighting, perform an additional spot check for hot spots and uniformity using the point-by-point method.

Constants such as lumen output per lamp, fixture efficiency, maintenance factor, or coefficient of utilization, shall be shown with the source of the constants identified, such as a product cut sheet. In most cases, the maintenance factors should be chosen on the basis of a medium-intensity maintenance program, full rated voltage applied, no temperature derating, and a 5% tolerance for

lamp burnout. Coordinate expected wall, ceiling, and floor reflectances with architectural finishes and explain significant excursions from the 80/50/20% standard.

Calculate the vertical illumination level for those rooms and spaces where adequate illumination on walls, display cases and boards, or shelves is important to the mission of the room.

Calculate the visual comfort probability in the manner described in the IESNA Handbook for all rooms in excess of 40 feet in length and width, or when directed by the Electrical Design Criteria. Where other than "white light" (low CRI, or significantly off 3,500°K) is used, calculate the human eye response to the spectrum provided and provide the equivalent effective illumination level had "white light" been used.

Specify the operating point of adjustable automatic switching controllers, such as at what ambient conditions the controllers are to function both on and off. Include delay times and sensitivity settings for occupancy sensors, ambient light levels for daylight harvesting controls, timer settings, Facilities Control System interconnections, etc.

Use the point-to-point method to develop isolux curves for design of parking, ground, flood, or perimeter fence lighting systems to design the required horizontal foot-candle levels and uniformities at ground level. Submit the isolux curves as part of the design package.

Options for calculations include commercial software programs explained in the IESNA Handbook. Identify the program used by trade name and version number.

9.13.6 Exterior Lighting Calculations

Use isolux curves to design ground or fence lighting systems to obtain the required minimum footcandle level, horizontal, at ground level. Submit the isolux curves used for cross-checking.

9.13.7 Harmonic Analyses Calculations

Prepare harmonic study calculations when a significant amount of harmonic (nonlinear) load is added to the distribution or building power system. A harmonic study will also be required when the new load exceeds the recommended voltage or current distortion levels as allowed per by IEEE-519-1992, "Recommended Practices and Requirements for Harmonic Control in Electric Power Systems."

The design shall include a system that limits the voltage and current distortion at the point of common coupling per the limits recommended by IEEE 519-1992. Sandia/NM will provide the existing power system information.

The results of the harmonic study will dictate when additional harmonic correction measures are required.

9.14 Access and Layout

- Electrical equipment shall be accessible for periodic maintenance, repair and replacement.
- Anticipate and eliminate head-bumping or tripping hazards.

- Locate lighting fixtures so access for re-lamping and repair activities is maintained.
- Prepare elevations of crowded walls, particularly where the mechanical and structural equipment used for the maintenance of electrical equipment is located.
- Coordinate information on Electrical drawings with the Structural drawings so sleeves through walls and floors are accurately detailed and specified.
- Coordinate with Mechanical/HVAC drawings so each system will properly fit into common spaces.

9.15 Sandia Furnished Material

Unless specifically indicated in the Electrical Design Criteria, Sandia/NM will furnish the following equipment:

- Emergency light system inverter
- S&C switchgear
- Oil-filled pad mounted Transformers (>600 volts, primary)

9.16 Acceptance Testing

Acceptance Testing is required on all new electrical equipment prior to energizing and placing into service. Testing will be performed by a third party, testing firm, meeting all qualifications as stated in the latest edition of the InterNational Electrical Testing Association (NETA) document, ATS-Latest Edition, “Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems”. Also, all acceptance testing shall be performed in accordance with the latest edition of NETA ATS-Latest Edition, “Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems”.

- End of Chapter -

Chapter 10 - Telecommunications Design Standards

Design the telecommunications systems per the separate Telecommunications Systems Design Manual dated November 11, 2004, as available in its most current revision date on Sandia's Engineering Standards web site.

Ownership of this Chapter of the Design Manual rests in Sandia department 9334, Network Design and Implementation, and department 9335, Corporate Computing Infrastructure and Support Operations. Contact Merle Bensen, (505)844-0724, mail stop 0788, mjbenso@sandia.gov, for network engineering support. . Contact John Dexter, (505)284-3097, mail stop 0809, jhdexte@sandia.gov, for telecommunications engineering support. Contact the Telecommunications Trouble Desk, (505)845-8509, for all other questions.

- End of Chapter -

Chapter 11 - Security Design Standards

NOTE: Ownership of this Chapter of the Design Manual rests in Sandia department 4214, Technical Security Systems. Contact Jerry A. Brenden, (505)284-9100, mail stop 0864, jabrend@sandia.gov, for support and for access to restricted specifications and drawings.

11.1 Introduction

An intrusion alarm (IA) system is required for all permanent buildings at Sandia/NM Mobile offices, T-buildings, and other temporary structures do not have IA systems unless required by the Security Plans, Requirements, or Department 3111, Risk Management/Physical Security. IA system designs shall be similar to the IA design for the building being modified. Do not interface the IA system with other special systems unless approved by Sandia/NM Electronic Security Department.

No splices are allowed in IA cables except where required for connection to alarm devices or in splice cases at communication manholes. All splices must be protected by a tamper switch.

Specify lightning arrestor/surge protection devices to protect multiplexers installed in a new structure or in any location subject to induced voltages and currents caused by lightning or other sources.

11.2 Tech Area I and IV Intrusion Alarm System

The IA system in Tech Areas I and IV consists of the following major components:

11.2.1 Facilities Command Center (FCC)

The FCC in Building 956 monitors alarms and logs the alarm's status onto the primary VAX computer. Maps displayed on graphics terminals show the status of all alarm points north of Tijeras Arroyo (Tech Areas I, II, IV, and the 6000 Igloo Area). The secondary VAX computer is located in the Headquarter Commend Center (HCC), is located in the basement of Building 802, and provides additional redundancy and security.

11.2.2 Multiplexer Control Units

Multiplexer control units (MCUs) are situated in key buildings throughout Tech Areas I and IV. They poll Stellar multiplexers for alarm status and report the accumulated alarm data to the FCC and HCC through twisted pairs. Each MCU has four input and four output ports that support four multiplexer communication loops. MCUs are operated in pairs to provide redundant communication loops to the multiplexers and to the FCC and HCC.

The MCU pair locations are:

- Building 802 MCU–Building 807 MCU
- Building 892 MCU–Building 894 MCU

- Building 880 MCU–Building 858 MCU
- Building 821 MCU–Building 960 MCU
- Building 836 MCU–Building 860 MCU
- Building 891 MCU–Building 891 MCU

MCUs and MCU loop design are not required in a typical IA project unless a special compartmentalized information facilities area is being installed.

11.2.3 Multiplexer Cabinets

Multiplexer cabinets are standardized pre-wired cabinets that come in one cabinet size: a 3- by 3-foot cabinet with a maximum of six Stellar multiplexers. The cabinet contains all necessary components for the monitoring of alarms, including a pre-wired cabinet tamper switch and a power failure alarm.

Each Stellar multiplexer contains eight channels for alarm input from field alarm detection devices. Four of the channels have a dual alarm level capable of monitoring both the alarm and tamper conditions on a single pair of wires. These channels are used for devices that have both alarm and tamper, such as a door switch or motion sensor, or other alarm detection devices. The other four channels are capable of only one level of alarm or tamper condition. The single-alarm level channels are used for tamper switches, duress switches, power failure, and other single-contact-type alarms.

11.3 Tech Area V Alarm System

The IA system in Tech Area V is identical to the system in Tech Area I with the exception of the alarm communication wiring layout. Unlike the system in Tech Area I, the multiplexer cabinets in Tech Area V are concentrated in groups of two or more in dedicated locations throughout the area to simplify access for maintenance and troubleshooting. A customized multiplexer cabinet in the Building 6581 monitors the dedicated telephone pairs transmitting alarm status data from buildings in Tech Area III and the remote areas.

The primary VAX computer is located in building 6578 (AGATE) which is the Central Alarm Station (CAS) and the secondary VAX computer is located in building 6581, which is the Secondary Alarm Station (SAS). The CAS and SAS monitors alarm points in Tech Area V, building alarms in Tech Area III, and alarms in remote areas.

Design the Tech Area V IA system in a manner similar to the design shown in the Tech Area V alarm system drawing, old series # 99085.

11.4 Tech Area III and Remote Area Alarm System

The alarm detection devices for buildings in Tech Area III and remote areas are divided into zones, typically one zone for each building. Consult with personnel in the Sandia/NM Electronic Security Department to define the zones. An alarm and a tamper circuit are routed from an IA cabinet to each alarm device. The alarm and tamper circuits are terminated on separate terminal blocks in the IA cabinet and each circuit is connected in series to form zones.

Specify a 1/2-inch conduit with a telephone pair to the nearest telephone cabinet. A dedicated telephone pair is required from the telephone cabinet in the alarmed building to the LOOP #4 multiplexer cabinet in building 6581 in Tech Area V. The Sandia/NM Electronic Security department will contact the Communications Department to obtain a dedicated telephone pair.

For new installations, specify a six-conductor cable (Belden 9576) from the IA cabinet to each alarm detection device. For existing installations that use #18 conductors for alarm detection device wiring, specify #18 conductor color-coded purple for the alarm circuits and orange for the tamper circuits.

11.5 6000 Igloo Alarm System

A Vindicator alarm system is used to monitor alarms in the 6000 Igloo area. Each area has an independent Vindicator alarm station located in the guard shack, which monitors the status of alarm points in the area and displays the information on an LED panel. The Vindicator alarm system reports a duress alarm to the Tech Area I FCC through Dorado modems and a dedicated telephone pair. Design the 6000 Igloo alarm system in a manner similar to the design shown on Drawings 96383 E-23 through E-27.

11.6 Vault Room Requirements

When a request for a new vault or vault-type room is received, obtain the latest Sandia/NM Corporate Process Requirement document No: CPR400.3.9. An official version is located on the Sandia/NM Restricted Network (SRN). If the SRN is not accessible, contact Department 3111, Risk Management / Physical Security.

Consult with the Sandia/NM Electronic Security Department for the type and location of sensors to be installed in the vault room. Provide, if available, a layout of the room showing all furniture and heating and cooling equipment to assist the Sandia/NM Electronic Security Department personnel in the proper placement of infrared and microwave space alarm detection devices.

Provide an IA multiplexer cabinet in or near the vault room. It is recommended that the cabinet be installed outside the vault room for easy access by IA system personnel. An existing multiplexer cabinet near the vault room may be used if the alarm capacity of the cabinet is not exceeded. To reduce the voltage drop, avoid excessive distance between the multiplexer cabinet and the vault room sensors.

Provide a sensor power on/off switch inside the vault room to allow the vault owner to turn off power to the space sensors when the vault is in the access mode. This prevents the premature failure of sensor alarm contacts that otherwise would continually operate if the sensor was energized while the vault was occupied. Install the sensor power on/off switch in a location where it will not be mistaken for a light switch. Mount the switch on the multiplexer cabinet if the cabinet is in the vault room. Label the switch IA SENSOR POWER.

Sensitive Compartmented Information Facilities (SCIFs) require a self-contained independent alarm system. Consult with personnel in the Electronic Security Department for the design

guidelines of these special areas. For vault rooms that meet the NFPA definition of a vault, NFPA 232 shall be followed as well as security requirements. Contact Sandia/NM Facilities Fire Protection Engineering before applying the requirements of NFPA 232 unless this requirement is specified in the Design Criteria.

11.7 Drawings Required

The following drawings (marked and protected as Official Use Only) are required when modifying or installing a new IA system:

- Building IA floor plans.
- IA Standard Equipment List Drawing, # TY6001STD (old # 91303 E-8).
- IA Standard Terminal cabinet wiring diagrams Drawing, # TY7001STD (old # 91303 E-4).
- IA Standard MUX cabinet elementary diagrams Drawing, # TY7003STD (old # 91303 E-5).

The following drawings are required in the construction drawing set when a new multiplexer cabinet is being installed:

11.7.1 Wiring Diagrams for 36- by 36- by 6-inch Multiplexer Cabinet

- For terminal cabinet wiring diagram use Standard Drawing # TY7001STD (old # 91303 E-4) as a template.
- For multiplexer loop elementary diagram use Standard Drawing # TY7004STD (old # 91303 E-6) as a guideline.

11.7.2 Fabrication Drawings

- IA Standard Drawing # TY6001STD (old # # 91303 E-8).
- Multiplexer cabinet details IA Standard Drawing # TY7008STD (old # # 91303 E-12).
- Multiplexer/tamper switch bracket details IA Standard Drawing # TY5005STD (old# 91303 E-14).

Draw the multiplexer cabinet wiring diagrams per requirements in the Sandia/NM's Facilities CADD Standards Manual for level schemes for IA wiring diagram drawings.

Use IA Standard Drawing # TY6001STD (old # 91303 E-8) when specifying IA equipment. The standard drawing may be copied, given a new drawing number, and issued with the building drawing package, if desired. Do not add or modify equipment items on IA Standard Drawing, # TY6001STD (old # 91303 E-8) without permission from the Engineering Standards Program Committee.

11.8 Construction Standard Specifications

When modifying or installing a new IA system, issue Facilities Construction Standard Specification Section 16720, Intrusion Alarm System (for Official Use Only).

11.9 Multiplexer Cabinet

A multiplexer cabinet is typically modified or specified during any IA system design that will be using Stellar multiplexers for monitoring alarm devices. The procedures to design a new multiplexer cabinet for an IA system design are:

- Specify the standard cabinet: 3-foot by 3-foot by 6-inch cabinet (contains a total of 23 alarm/tamper channels and 22 tamper-type alarm channels for connection to alarm detection devices)
- Select the number of Stellar multiplexers required in the cabinet. Cabinets are pre-wired for a maximum of six multiplexers per cabinet. Shunt cards, available from Sandia/NM Electronics Security Department, are used to plug into the communications connector for multiplexers that are not installed to maintain communication continuity. Indicate on the multiplexer cabinet elementary diagram cabinet detail which multiplexers are for future use and have the shunt card installed.
- Issue the proper fabrication drawings listed in Chapter 2 for the selected cabinet.
- Locate cabinets in an accessible location; preferably outside vault rooms and other restricted areas.
- Specify 120 VAC power to the receptacle in the cabinet and label the circuit number on the receptacle.
- Specify a six-pair #22 shielded cable (Belden 8768 or equal) to the nearest location to access an MCU multiplexer loop (typically the nearest multiplexer cabinet or in a communications manhole). The maximum allowable distance between multiplexer cabinets is 2000 feet. The IA system maintenance personnel will make the connections into the active MCU multiplexer loop to avoid creating a disruptive multiplexer loop failure. Terminate the six-pair cable on punchdown Block A on the outside terminal prongs A1 through A18.
- Specify conduit and cable to alarm detection devices.

11.10 Alarm Device Terminations

Specify an ADT (formerly Wells Fargo) SM-4 balanced magnetic door switch and MB 4 spacer or a Sentrol balanced magnetic door switch 2707 AD for surface mounted and 2757D for a recessed at each exterior entrance door and vault perimeter door. Specify a Sentrol 2807T explosion-proof balanced magnetic door switch in hazardous locations. At each exterior roll-up door, exterior elevator door, or any other door that has a wide tolerance range in the closed position, install a Sentrol #2747A balanced magnetic switch on a #1961 L-mounting bracket.

Specify glass breakage detectors on perimeter windows that are not rated as security glass.

The alarm detection devices listed below, although not all inclusive, are commonly used in an IA system. No substitutes are allowed without the permission of the Electronic Security Department.

- Balanced magnetic switches: ADT (formerly Wells Fargo) (P/Ns SM-3, SM-4), Sentrol (P/N 2747A), (P/N 2707AD), (P/N 2757D).

- Passive infrared sensors: Aritech (P/Ns DR486, DR550, AP 633, AP669, DR851)
- Microwave space sensors: PROTECH (HITECH EX Series Explosion proof P/N HT 100EX, Passive Infrared/Microwave SDI-76 SDI-77, HT-50, HT-100)
- Tamper switch: Honeywell, Microswitch P/N 2AC6
- Window breakage detector: International Electronics (P/Ns IE1-725L, IE1-743).

The Designer shall coordinate submittals with the Sandia/NM Electronic Security Department for the procurement of the Intrusion alarm sensors and related parts.

11.11 Wiring

Specify all field cable and IA multiplexer cabinet cables as called out in the IA Standard Drawings. No variations of the cable color codes are allowed.

Specify a six-conductor #22 cable (Belden 9576 or equal) from the IA multiplexer cabinet to each alarm detection device. Specify a 5100-ohm and a 750-ohm resistor in each door switch/sensor and specify cable conductors to be terminated per the instructions on IA Standard Drawing, Sensor Details, # TY5004STD (old # 91303 E-7). Where feasible, route cable through the door mullion to the switch housing of a door switch to reduce the number of conduit, flexible conduit, and J-boxes visible below the ceiling.

11.12 Interface with Sandia/NM Security and Maintenance Departments

IA modifications, no matter how small, need coordination with Sandia/NM Electronic Security Department in the design stages. Obtain approval from Department 3111, Risk Management / Physical Security, when a project requires the installation of a vault or a vault-type room.

Consult with personnel in the Sandia/NM Electronic Security Department for space sensor layout inside a vault or vault-type room.

Upon completion of Title II design, review the design with representatives from the Sandia/NM Electronic Security Department. Document design acceptance on the project folder.

Upon completion of the design for new work, removals, or the relocation of any component in the IA system, or when construction change orders change the original design, provide one set of floor plans and multiplexer cabinet wiring and elementary plans to the supervisors of the Sandia/NM Electronic Security Department.

- End of Chapter –

Chapter 12 - Attachments

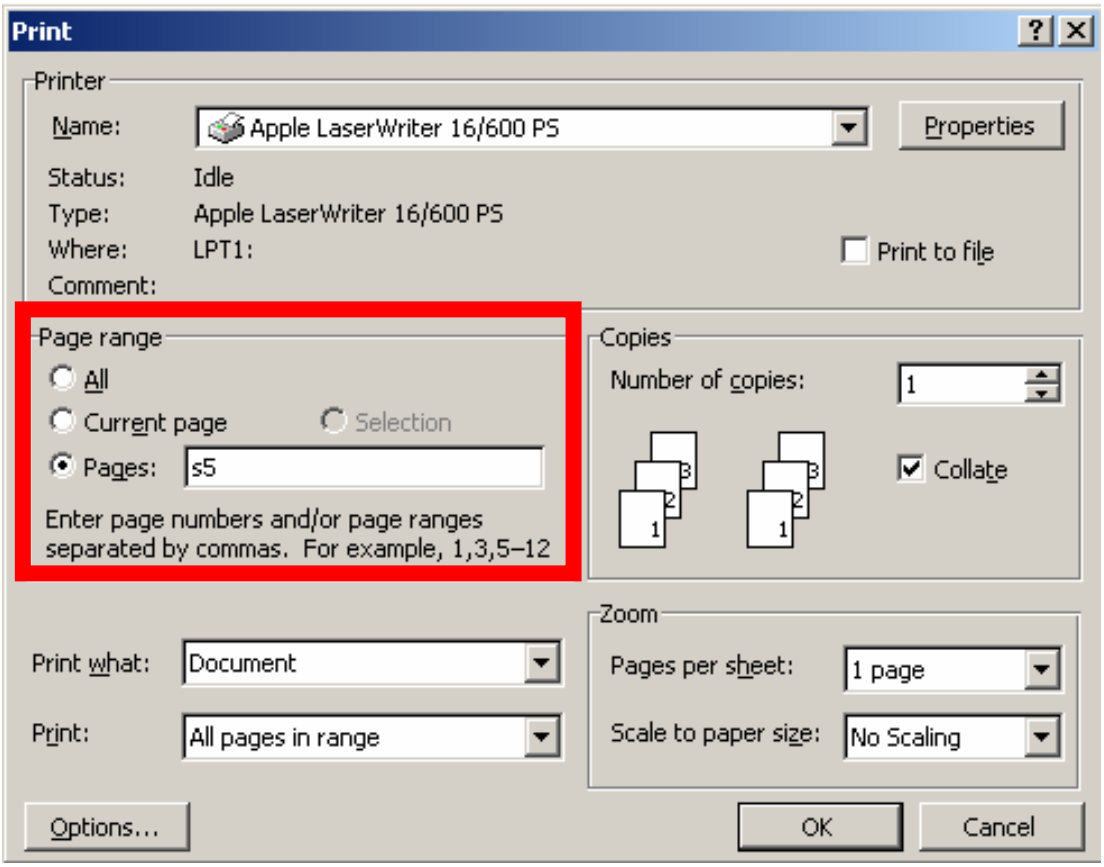
12.1 Attachment 1 – Instructions for Printing the Design Manual by Chapters

The Facilities Design Standards Manual is divided into several chapters and the accompanying front matter (the title page, table of contents, list of tables, and acronyms and abbreviations). If you don't want to print the entire document, Word allows you to print individual chapters of the manual by printing sections of the document. However, the section numbers don't match the chapter numbers. The following instructions should help you to print the chapters or pages that you want.

1. The manual is divided into the following chapters. The corresponding section number(s) for each chapter are listed on the right.

2. Go to the Engineering Standards URL (http://www.sandia.gov/engstds/dsnmanual.html) and click on the Design Standards Manual file to open it. Read the Table to find the pages you want to print.

3. To print a single chapter, choose “Print” from the “File” menu. The Print dialog box will appear (see the image below). Under “Page Range”, click in the box next to “Pages” and type the section number of the chapter you wish to print, using the format s#. In the example below, I’ve asked to print Section 5 (s5), which corresponds to Chapter 1. Click OK to print.



4. You can print multiple chapters by entering their section numbers. To print Chapters 1 (Section 5) through 6 (Section 10), for example, type “s5-s10” in the Pages box. To print Chapters 1 (Section 5), 3 (Section 7), and 7 (Section 11), type “s5, s7, s11” in the box.
5. You can also print a few pages from a chapter, using the format “p#s#”. For example, to print pages 20 through 25 of Chapter 8 (Section 12), type “p20s12-p25s12” in the Pages box.

If you have any questions, contact John Zavadil at 844-5366.

- End -

12.2 Attachment 2
Variances from Engineering Standards Program Requirements
Example: Building 969 Design/Built Project

Design completed: Design/Built contract
Construction complete: Projected completed by 9/04

Civil Variances
None Identified

Landscaping Variances
None Identified

Structural Variances
None Identified

Architectural Variances
None Identified

Fire Protection Variances
None Identified

Mechanical Variances
None Identified

Electrical Variances

Section	Description	Benefit	Approval
2.2.6S	Allow mechanical connectors that meet the requirements of UL96A to be used instead of exothermic connectors.	The reason for the change is to reduce construction costs, to improve worker safety, and to reduce cycle times.	Florian Lucero Jr. The Facilities Electrical Systems Engineers have also approved this change to future standard specifications.

Telecommunications Variances
Allow cast-in-place telecommunication manhole instead of precast manhole. The reason for the variance is to allow for construction of the manhole around an existing telecommunications duct bank.

Section	Description	Benefit	Approval
1.1.2S	Allow cast-in-place telecommunication manhole instead of precast	The reason for the variance is to allow for construction of the	Jay Peterson Telecommunications Systems.

	manhole.	manhole around an existing telecommunications duct bank.	

Security Variances
None Identified

- End -

12.3 Attachment 3.A – Design Reference Guide

SYSTEM	DESIGN GUIDES	SPECIFICATION SECTIONS	Title
Water Lines (Domestic and Fire Protection)	**Sandia/NM Design Manual Chapter 3.4.1**	**SNL 02665**	Underground Water Lines for Domestic and Fire Protection Systems
Sanitary Sewer	**Sandia/NM Design Manual Chapter 3.4.2**	**SNL 02720**	Storm Sewer Systems (Replaced 15 E)
		SNL 02725	Sewer Manholes
		SNL 02730	Sanitary Sewer Systems
		SNL 02955	Sewer Flow Control
		SNL 02957	Sewer Pipe Lining
		SNL 02958	Manhole Rehabilitation
Natural Gas	**Sandia/NM Design Manual Chapter 3.4.3**	**SNL 02553**	Exterior Gas Piping Systems (Replaced 02685)
Liquefied Petroleum Gas	**Sandia/NM Design Manual Chapter 3.4.4**	**No Standard Specifications**	
Storm Drain	**City of Albuquerque DPM and SNL Design Manual Chapter 3.4.5**	**COA SECTION 100**	
		101	Portland Cement Concrete
		102	Steel Reinforcement
		103	Epoxy - Coated Steel Reinforcement
		105	Concrete Curing Compound
		106	Cement Mortar and Grout
		107	Join Filler and Sealant Material
		109	Riprap Stone
		111	Colored Portland Cement Concrete
		112	Paving Asphalt (Asphalt Cement)
		114	Asphalt Paving Hot Recycling
		115	Slurry Seal Materials
		116	Asphalt Concrete
		117	Asphalt Rejuvenating Agents
		119	Paving Fabrics
		123	Reinforced Concrete Pipe
		124	Reinforced Concrete Pressure Pipe
		135	Corrugated Metal Pipe and Arches
		136	Structural Steel Plate for Pipe, Arches and Pipe Arches
		137	Corrugated Aluminum Pipe and

SYSTEM	DESIGN GUIDES	SPECIFICATION SECTIONS	Title
			Arches
		138	Pipe Arches and Box Culverts
		139	Structural and Rivet Steel, Rivets, Bolts, Pins and Anchor Bolts
		157	Paint
		160	Steel Castings
		170	Electronic Marker Disks
Storm Drain - Cont.		**COA SECTION 600**	
		601	Earthwork for Open Channels, Dikes or Dams
		602	Portland Cement Concrete for Channel Lining and Dike or Dam Surfacing
		603	Riprap Surface Treatment
		604	Flexible Soil Mattings
		610	Gabions
		COA SECTION 900	
		910	Storm Sewer Pipe Installations
		915	Storm Sewer Drainage Appurtenances
		920	Sanitary and Storm Sewer Manholes
Site Work	**Sandia/NM Design Manual Chapter 3.5**	**SNL 02200**	Earthwork
		SNL 02222	Selective Demolition
Fencing	**Sandia/NM Design Manual Chapter 3.5.2**	**SNL 01531**	Temporary Fencing
		SNL 02444	Chain Link Fences and Gates
		SNL 02445	Barbed Wire Fences
Paving & Road Construction	**Sandia/NM Design Manual Chapter 3.5.4**	SNL ???	
		COA SECTION 100 - See COA Section 100 in Storm Drain	
		COA SECTION 200	
		201	Clearing and Grubbing
		202	Roadway Excavation
		204	Fill Construction
		205	Borrow Excavation
		207	Lean Fill Construction

SYSTEM	DESIGN GUIDES	SPECIFICATION SECTIONS	Title
		210	Open Area Land Leveling
		COA SECTION 300	
		301	Subgrade Preparation
		302	Aggregate Base Coarse Construction
		304	Lime Treated Subgrade and/or Subbase
		305	Cement Treated Base Construction
		306	Bituminous Stabilized Base and Surfacing
		307	Plant Mix Bituminous Treated Base Construction
		308	Natural Gravel Surfacing for Unpaved Roadways
		320	Utility and Monument Access Cover Adjustments
		329	Plant Mix Seal Coat
		330	Asphalt Emulsion Slurry Seal
		331	Asphalt Concrete Overlay
		332	Heater-Remix Resurfacing
		333	Fog Seal Coat
		334	Seal Coat and Chips and Precoated Chip Seal Coat
		335	Paving Fabric Installation
		336	Asphalt Concrete Pavement
		337	Portland Cement Concrete Pavement
		340	Portland Cement Concrete Curbs, Gutters, Walks, Driveways, Alley Intersections, Slope Paving, and Median Paving
		341	Extruded Asphalt Curb
		342	Soil Sterilization
		343	Removal and Disposal of Existing Pavements, Curbs, Gutters, Sidewalks, and Drivepads
		344	Cold Milling of Pavement Surfaces
		346	Textured Concrete
		347	Brick Sidewalk
		348	Brick Pavement Surface
		349	Concrete Curing

SYSTEM	DESIGN GUIDES	SPECIFICATION SECTIONS	Title
Curb and Gutter	Sandia/NM Design Manual Chapter 3.5.4	COA SECTION 300 - See Section 300 Paving	
Road Design	Chapter 3.5.4 AASHTO, a Policy On Geometrical Design of Highways and Streets, Latest Ed.		
Landscape	Sandia/NM Design Manual Chapter 3.5.6 & Campus Design Development Guidelines	SNL - Specification Under Development	
Utility Removal	Sandia/NM Design Manual Chapter 3.5.7	No Standard Specifications	
Drainage Design	City of Albuquerque DPM and Sandia/NM Design Manual Chapter 3.6.1	Not Applicable	
NPDES and SWPPP	Sandia/NM Design Manual Chapter 3.6.2 (Referenced Documents)	Not Applicable	
Hydrology Criteria	City of Albuquerque DPM Section 22	Not Applicable	
Hydraulic Design	City of Albuquerque DPM Section 22.3	Not Applicable	
Surveying	Sandia/NM Design Manual Chapter 3.7	Not Applicable	

12.4 Attachment 3.B – List of Approved Civil Standard Drawings

	Sandia *UDS File Name*	City of Albuquerque *COA Ref Drawing DWG. #*	*Discipline*	*Sub-Discipline*	*Title*	*Drawing Type*
Exterior Utilities						
Water						
	WW3001STD.dgn	N/A.	Civil Work	Water	Water Valve Box Section and Detail	Sections
	WW3002STD.dgn	N/A.	Civil Work	Water	Valve and Post Indicator Section	Sections
	WW5001STD.dgn	N/A.	Civil Work	Water	Fire Hydrant Details	Details
	WU5003STD.dgn	N/A.	Civil Work	Combined Utilities	Air and Vacuum Valve	Details
	WU5005STD.dgn	N/A.	Civil Work	Combined Utilities	Thrust Block Details	Details
		2353	Civil Work	Water	Water Surge Relief Valve Station	Details
		2380	Civil Work	Water	Water Boring Installation	Details
		2325	Civil Work	Water	Water Valve Stem Extension	Details
		2331	Civil Work	Water	Water Valve Stem Extension	Details
		2332	Civil Work	Water	Water Valve Box Adjustment	Details
Sanitary Sewer	WS5001STD.dgn	N/A.	Civil Work	Sanitary Sewer	Clean-Out Detail	Details
	WS5002STD.dgn	N/A.	Civil Work	Sanitary Sewer	Sewer Vent For Trailer Utility Block	Details
	WS5003STD.dgn	N/A.	Civil Work	Sanitary Sewer	Trailer Utility Block Plan	Details
		2111	Civil Work	Sanitary Sewer	Sewer Manhole Cover Adjustment Ring	Details
		2116	Civil Work	Sanitary Sewer	Sewer Vertical Drop at MH	Sections
		2118	Civil Work	Sanitary Sewer	Sewer Service Line Connections at Manhole	Sections
		2125	Civil Work	Sanitary Sewer	Sewer Service Line Details	Details
		2134	Civil Work	Sanitary Sewer	Sewer Service Replacement Detail	Details

	Sandia *UDS File Name*	City of Albuquerque *COA Ref Drawing DWG. #*	*Discipline*	*Sub-Discipline*	*Title*	*Drawing Type*
		2135	Civil Work	Sanitary Sewer	Sewer Riser Details Rigid Pipe Main	Details
		2136	Civil Work	Sanitary Sewer	Sewer Riser Details Flexible Pipe Main	Details
		2140	Civil Work	Sanitary Sewer	Sewer Encasement Detail	
		2150	Civil Work	Sanitary Sewer	Sewer Sampling & Metering Manhole 6' X 8' Rectangular	Sections
		2151	Civil Work	Sanitary Sewer	Sewer Sampling & Metering Manhole 8 Foot Diameter	Sections
Natural Gas						
	WG3001STD.dgn	N/A.	Civil Work	Natural Gas	Gas Valve Box Section	Sections
	WG5001STD.dgn	N/A.	Civil Work	Natural Gas	Gas Valve and Line Detail	Details
	WG5002STD.dgn	N/A.	Civil Work	Natural Gas	Gas Valve Box Detail	Details
	WG5003STD.dgn	N/A.	Civil Work	Natural Gas	Test Box Detail	Details
	WG5004STD.dgn	N/A.	Civil Work	Natural Gas	Marker Post with Test Box Detail	Details
	WG5005STD.dgn	N/A.	Civil Work	Natural Gas	Tracer Wire Details	Details
	WG5006STD.dgn	N/A.	Civil Work	Natural Gas	Warning Tape and Tracer Wire Detail	Details
	WG5007STD.dgn	N/A.	Civil Work	Natural Gas	Gas Meter Detail	Details
	WG5008STD.dgn	N/A.	Civil Work	Natural Gas	Valve Stem Extension Detail	Details
Liquefied Petroleum Gas					*No Standard Drawings Listed*	
Storm Drain						
	WR5001STD.dgn	N/A.	Civil Work	Storm Drain	Manhole Types "C" and "E" Drainage	Details
	WR5002STD.dgn	N/A.	Civil Work	Storm Drain	New Pipe In Existing Drainage Structure	Details
	WR5003STD.dgn	N/A.	Civil Work	Storm Drain	Dry Well Detail	Details
	WR3001STD.dgn	N/A.	Civil Work	Storm Sewer	Single "C" Storm Inlet	Sections

	Sandia *UDS File Name*	City of Albuquerque *COA Ref Drawing DWG. #*	*Discipline*	*Sub-Discipline*	*Title*	*Drawing Type*
	WR5001STD.dgn	N/A.	Civil Work	Storm Sewer	Manhole Types "C" and "E" Drainage	Details
	WR5002STD.dgn	N/A.	Civil Work	Storm Sewer	New Pipe In Existing Drainage Structure	Details
	WR5003STD.dgn	N/A.	Civil Work	Storm Sewer	Dry Well Detail	Details
		2202	Civil Work	Storm Drain	Drainage Storm Inlet Type "A" Sections B-B, C-C, D-D, & E-E	Sections
		2203	Civil Work	Storm Drain	Drainage Storm Inlet Type "B"	Sections
		2205	Civil Work	Storm Drain	Drainage Storm Inlet Double "C"	Sections
		2206	Civil Work	Storm Drain	Drainage Storm Inlet Double "D"	Sections
		2207	Civil Work	Storm Drain	Drainage Storm Inlet Gutter Transition	Details
		2215	Civil Work	Storm Drain	Drainage Strom Inlet Center Support Assembly	Details
		2216	Civil Work	Storm Drain	Drainage Strom Inlet Frame	Details
		2220	Civil Work	Storm Drain	Drainage Storm Inlet Albuquerque Grate	Details
		2225	Civil Work	Storm Drain	Drainage Slotted Drain	Sections
		2229	Civil Work	Storm Drain	Drainage Aluminum Step Detail	Sections
		2235	Civil Work	Storm Drain	Drainage Drain Line Through Curb	Sections
		2236	Civil Work	Storm Drain	Drainage Sidewalk Culvert With Steel Plate Top	Sections
		2237	Civil Work	Storm Drain	Drainage Drain Line Connection to Exist. Storm Inlet	Sections
		2252	Civil Work	Storm Drain	Drainage Standard Chain Link Gate and Fence Details	Details
		2260	Civil Work	Storm Drain	Drainage Typical Lining for Drainage Easements	Details
		2261	Civil Work	Storm Drain	Drainage Channel Details	Details
		2265	Civil Work	Storm Drain	Drainage Channel Expansion Joint with Sleeper	Details
		2266	Civil Work	Storm Drain	Drainage Expansion Joint Connection to Concrete Wall	Details
		2267	Civil Work	Storm Drain	Drainage Channel Expansion Joint Repair	Details
		2270	Civil Work	Storm Drain	Drainage Wire Enclosed Riprap	Details
Combined Utilities						

	Sandia *UDS File Name*	City of Albuquerque *COA Ref Drawing DWG. #*	*Discipline*	*Sub-Discipline*	*Title*	*Drawing Type*
	WU3001STD.dgn	N/A.	Civil Work	Combined Utilities	Utility Crossing at Pavement	Sections
	WU5006STD.dgn	N/A.	Civil Work	Combined Utilities	Utility Markers for Buried Pipe and Cable	Details
	WU5007STD.dgn	N/A.	Civil Work	Combined Utilities	Hand Hold In Steam Pits	Details
Site Work						
Grading					*No Standard Drawings Listed*	
Fencing	CJ1004STD.dgn	N/A.	Civil	Improvements	Roof Top Temporary Fencing (Temporary Construction Fence)	Elevations
	CJ1005STD.dgn	N/A.	Civil	Improvements	16 ' Security Fence	Elevations
	CJ1006STD.dgn	N/A.	Civil	Improvements	Cantilever Slide Gate	Elevations
	CJ1007STD.dgn	N/A.	Civil	Improvements	Barbed Wire Fence	Elevations
Site Work					*No Standard Drawings Listed*	
Sidewalks	CP1008STD.dgn	N/A.	Civil	Paving	Standard Sidewalk Layout	Plans
	CP5002STD.dgn	N/A.	Civil	Paving	Concrete Walks with Exposed Aggregate Bands	Details
		2430	Civil	Paving	Paving Sidewalk Details	Details
		2431	Civil	Paving	Paving Sidewalk Obstructions	Details
		2432	Civil	Paving	Paving Sidewalk Transitions	Details
		2440	Civil	Paving	Paving Wheel Chair Ramp	Details
		2441	Civil	Paving	Paving Wheel Chair Ramp	Details
Roads, Traffic, and Paving	CP1001STD.dgn	N/A.	Civil	Paving	Crosswalk Marking	Plans

	Sandia *UDS File Name*	City of Albuquerque *COA Ref Drawing DWG. #*	*Discipline*	*Sub-Discipline*	*Title*	*Drawing Type*
	CP3002STD.dgn	N/A.	Civil	Paving	Asphalt Pavement Sections	Sections
	CP5001STD.dgn	N/A.	Civil	Paving	Precast Concrete Bumper	Details
		2401	Civil	Paving	Paving Typical Residential Street Intersection	Details
		2415	Civil	Paving	Paving Curb and Gutter & Temporary Paving Section	Sections
		2418	Civil	Paving	Paving Mountable to Standard Curb Transition	Sections
		2420	Civil	Paving	Paving Concrete Valley Gutter	Sections
		2421	Civil	Paving	Paving Concrete Valley Gutter	Sections
		2422	Civil	Paving	Paving Concrete Valley Gutters	Sections
		2425	Civil	Paving	Paving Drive Pads	Sections
		2426	Civil	Paving	Paving Private Entrance Details - Illustrating Two Separate R/W Conditions	Details
		2450	Civil	Paving	Paving Concrete Joints	Details
		2460	Civil	Paving	Paving MH & Valve Box Regrading	Details
		2465	Civil	Paving	Paving Citywide Pavement Cuts for all Utilities	Details
Traffic		2501	Civil	Traffic	Traffic Standard Transition	Details
		2502	Civil	Traffic	Traffic Typical Street Intersection Plan	Details
		2503	Civil	Traffic	Traffic Typical Street Intersection Plan	Details
Traffic Continued		2512	Civil	Traffic	Traffic Hammer Head Cul-De-Sacs	Details
		2529	Civil	Traffic	Traffic Bicycle Gateway	Details
Parking	CP1002STD.dgn	N/A.	Civil	Paving	6' Double Side Parking Bumper Layout	Plans
	CP1003STD.dgn	N/A.	Civil	Paving	8' Parking Bumper Layout	Plans
	CP1004STD.dgn	N/A.	Civil	Paving	8' Double Side Parking Bumper Layout	Plans
	CP1005STD.dgn	N/A.	Civil	Paving	6' and 8' Bumpers Parking Bumpers Layout	Plans
Landscape					Standards Are Under Development	

	Sandia *UDS File Name*	City of Albuquerque *COA Ref Drawing DWG. #*	*Discipline*	*Sub-Discipline*	*Title*	*Drawing Type*
Surveying						
Monuments	CP5003STD.dgn	N/A.	Civil	Paving	Survey Marker Vehicle Barrier Type "A"	Details
	CP5004STD.dgn	N/A.	Civil	Paving	Survey Marker Vehicle Barrier Type "B"	Details
		C.O.A. D.P.M. Figure 26.2	Civil	Monuments	City of Albuquerque Standard Brass Cap Installation in Earth	Details
		C.O.A. D.P.M. Figure 26.3	Civil	Monuments	City of Albuquerque Standard Brass Cap Installation in Bedrock or Large Boulder	Details

12.5 Attachment 4 – Additional Information and Requirements for Surveying

Types of Surveying

A. Boundary Surveying is the determination, description, portraying, measuring or monumentation of the boundaries of a tract of land. Other types of surveying, except as indicated, are not Boundary Surveying.
B. Topographic Surveying is the measurement and portrayal of the configuration of the ground and/or the location and description of objects thereon. It includes the plotting and description of property boundary monuments on a topographic map provided:
   (a) Only existing monuments found at the time of the survey are shown and not boundary monuments are set.
   (b) The following words are prominently shown on the topographic map: THIS IS NOT A BOUNDARY SURVEY. APPARENT PROPERTY CORNERS ARE SHOWN FOR ORIENTATION ONLY. BOUNDARY DATA SHOWN IS FROM PREVIOUS SURVEY REFERENCED HEREON.
C. Easement Surveying is the description, portrayal, or monumentation of easement(s) only.
D. Preparation of Legal Descriptions- The preparation of legal descriptions is a form of surveying and other than the citing of a lot or parcel of a duly recorded plat, must be performed by a licensed professional surveyor.
E. Unclassified Surveying is surveying not defined above.

Dimensions means the direction, expressed as a bearing or an azimuth and the length of a survey line.

Easement means a right that a person or an entity in the land of another.

Monument means an object intended to mark a property boundary.

Surveyor means a professional surveyor licensed under the Engineering and Surveying Practice Act.

Tract or Lot means a parcel of land in separate ownership or a leasehold or set off for separate ownership or a leasehold.

Boundary Surveying

When doing Boundary Surveying, the surveyor shall be responsible for accomplishing all of the following:

A. Obtain a copy of the last recorded deed and when available a copy of the title search for the tract being surveyed.
B. Review all recorded plats and all plats known to and available to the surveyor that are germane to the tract being surveyed.
C. Make a site visit and inspect the subject property and look for evidence of existing monuments and for evidence of possession and usage.

D. Determine the relative location on the ground of all found existing monuments, which pertain to the survey using procedures, which achieve the minimum accuracy standards.
E. Tag found monuments that are accepted by the surveyor and pertain to the survey with a metal tag, bearing the surveyor's registration number, attached to the monument with a metal wire or strap. Monuments that have been set by a government agency and are clearly identified by the markings need not be tagged.
F. Set new monuments in at all corners of the tract being surveyed using procedures that achieve the minimum accuracy standards, unless a permanent monument already exists.
G. Follow the rules and procedures, except for the accuracy and monumentation standards, in the Manual of Surveying Instruction prepared by the United States Bureau of Land Management, if the tract being surveyed pertains to the United States survey of public lands in any way including the following:
   (1) Is a section or and aliquot part of a section.
   (2) Is a small holding claim, private claim, land grant, mining claim or any other tract described in the Manual of Surveying Instructions.
   (3) Has a boundary, which is a boundary of a tract described in Subsection G Paragraphs (1) or (2) above.
   (4) Prior surveys and physical evidence within and adjacent to the section being surveyed should be carefully considered as evidence of original corner locations.
H. Never move, remove nor obscure an existing monument unless it is first properly referenced and all dimensions necessary to preserve its location are reported on a plat.
I. Updating a Prior Survey – If an existing survey is updated for any reason, the surveyor shall comply with the minimum standards in effect at the time of the update unless the update is only to correct a minor scrivener's error. If the update is solely to bring the survey into compliance with the minimum standards and the location of the boundary has not changed, re-monumentation is not required unless the original monumentation was not in compliance with the minimum standards in effect at the time the original survey was performed.
J. Prepare a plat of the survey, unless the survey is only the re-monumentation of corners of a tract, shown on a plat of record, where some of the existing corners of the tract are recovered, whose measured dimensions on the ground are reasonably close to the record dimensions. The play may contain as many sheets as required, which meet the size and material requirements of all applicable governing rules a regulations, and shall contain at least the following:
   (1) The name, address and registration number of the surveyor responsible for the survey.
   (2) A certificate followed by the dated signature and seal of the surveyor responsible for the survey stating that the surveyor conducted an actual survey on the ground and is responsible for the survey and that the survey and plat meet the Minimum Standards for Surveying in New Mexico. Only one surveyor's signature and seal shall appear on a plat. The following model certificates considered to be an example of the minimum the surveyor should certify to:

"I, _____, New Mexico Professional Surveyor No._____, do hereby certify that this Boundary Survey Plat and the actual survey on the ground upon which it is based were performed by me or under my direct supervision; that I am responsible for this survey; that this survey meets the Minimum

Standards for Surveying in New Mexico; and that is a true and correct to the best of my knowledge and belief.

_____, PS No._____ Date_____"

(3) A title which shall include the county in which shall include at least the following:
   (a) The lot, block or tract number and subdivision or district name if the survey is within a subdivision or conservancy district.
   (b) The city, grant, small holding, mining or private claim, or similar area in which the survey is located.
   (c) If neither paragraph (a) or (b) applies, then the section(s), township(s), and ranges(s) in which the survey is located. If the survey is not within a section, then the projected section(s) shall be stated and designated.

(4) A north arrow, equivalent scale and graphic scale for each sheet of the main drawing.

(5) The basis of bearings used in the survey shall be upon based on a procedure such as a solar observation or geodetic control stations or a line shown on a prior document and defined on the ground by existing monuments. The use of assumed bearings is prohibited.

(6) A description of all documents used to determine the boundaries and to prepare the plat of survey. The recording information shall be stated. If the document is not of record, all information used for the document shall be shown on the plat.

(7) The boundary being surveyed including the dimensions as measured on the ground and the record dimensions unless the two are equivalent in which case it shall be so stated; all dimensions which pertain to the determination of the tract boundaries, and a tie to a suitable, permanent, existing monument.

(8) All dimensions which pertain to the restoration of a lost or obliterated corner or the subdividing of a section in accordance with the rules and regulations pertaining to such subdivision.

(9) The location and description of any evidence of a boundary or line of occupation including such things as fence, building, hedge, wall or the remains thereof which is on a boundary or close enough to a boundary to be confused with the boundary.

(10) The location and description of all easements known or disclosed to the surveyor that cross, adjoin or serve a surveyed tract together with the recording data for the document that created the easement and the location and description of any visible structures which encroach upon said easement.

(11) The radius, central angle, length, and chord dimension including bearing for all curves.

(12) The lot number, tract number or other designation or the apparent owner of all adjoining tracts with the recording data of the as recorded plat.

(13) Reserved.

(14) The location and description of any evidence of use by a non-owner of the surveyed tract including such things as road, trail, path, pipeline or utility that crosses a boundary of the tract.

(15) A letter or number providing a unique designation of each surveyed tract on a plat with more than one tract.

(16) Reserved
(17) Access easement. If the surveyed tract is not contiguous to a public right-of-way, any access easement of record that is known to the surveyor shall be described on the plat and its location shall be determined. If no easement is known to the surveyor, a note prominently shown shall disclose that fact.
(18) The area of each surveyed tract and/or tract created by they survey.

Topographic Surveying

See Chapter 3.7, Surveying.

Easement Surveying

A. When doing Easement Surveying, the surveyor shall use procedures in any field measurements that achieve minimum accuracy standards.
B. If the easement does not run parallel to a boundary of the tract in which it is located, then the surveyor shall prepare a plat which shows the dimensions of the easement and complies with the following:
   (1) Show ties record monuments at the beginning and ending of the easement and at least at every mile along the easement, or
   (2) Shows the coordinates of the beginning, ending and all angle points in accordance with the New Mexico Coordinate System and shows the grid bearing and ground distance between said point, or
   (3) Shows ties to existing corner of subdivisions or sections in which the easement is located.
C. These field procedures and subsequent preparation must be conducted under the responsible charge of a professional surveyor.

Unclassified Surveying

When a surveyor does surveying of a type not described herein, the surveyor shall do all that is necessary to fully determine and report all information is relevant to the project. The scope of the project may be stated and limited.

Accuracy

The surveyor shall determine the class of a survey using the definition in the following Subsections A through C and achieve the accuracy specified in Subsection E for that class of survey. A closed traverse is not required if the surveyor uses procedures which will preclude blunders.

A. Urban means a survey within or adjoining a municipality or a survey, regardless of location, or land zoned for or intended use for multifamily, commercial or industrial purposes.
B. Suburban means a survey, which is not an Urban Survey of land zoned for or intended for use for residential purposes.
C. Rural means a survey is neither an Urban or Suburban survey.

D. Positional error means the error inherent in setting or measuring from a monument and is added to the error expressed as a ratio for closed traverse.

E. Minimum Field Accuracy Standards

	Urban	Suburban	Rural
Unadjusted Closure	1:15,000	1:10,000	1:7,500
Location of Improvements	0.10 ft	0.2 ft	1.0 ft
Positional Error	0.05 ft	0.10 ft	0.25 ft

Vertical Positioning

Level closures, running forward and backward between fixed elevations or loop closures, must be to the following accuracy:

$$0.05\,ft.\sqrt{M}$$

Where M is the distance in miles of the total level route, running forward and back between fixed elevations or along a level loop.

Monuments

See Chapter 3.7, Surveying.

12.6 Attachment 5 – Electrical Equipment Labeling Designations

12.6.1 Panelboard Labeling

See Table 14-1 for guidelines on how to label panelboards

Table 12-1. Panelboard Labeling Guidelines

Location	System	Voltage
B - Basement	B - Building Distribution	H - 480Y/277V
1 - First Floor	P - Process Distribution	L - 208Y/120V
2 - Second Floor	BS - Blue System	M – 120/240V
3 - Third Floor	X - Emergency Power	
4 - Fourth Floor	SB - Stand-by Power	
P - Penthouse	U - UPS Power	
W - Exterior		

Note: Buildings consisting of more than one floor shall have a **four-character** designation.

Example: BBH1	First character	B Indicates panel **Located** in basement
	Second character	B Indicates fed from Building Dist. **System**
	Third character	H Indicates panel **Voltage**
	Fourth character	1 Indicates **Consecutive Number** (per floor)

Note: Buildings consisting of a single floor shall not require a character denoting floor level. These panels shall be labeled with a **three-character** designation.

Example: BH1	First character	B Indicates fed from Building Dist. **System**
	Second character	H Indicates panel **Voltage**
	Third Character	1 Indicates **Consecutive Number**

Main Distribution Panels (MDPs) and Motor Control Centers (MCCs) shall be labeled numerically.

Example: MDP1, MDP2, MCC1. MCC2 etc.

12.6.2 Exterior Lighting Pole Labeling

Exterior lighting poles shall be labeled as follows:

Building Number, Panel Designation, Circuit Number and Pole Number.

Example:	**B-858**	Building 858
	BBH1	Panel BBH1
	15	Circuit 15
	P-3	Pole # 3

12.6.3 5 and 15 kV Transformer and Medium Voltage Switch Labeling

5 and 15kV Transformer and Switch labeling shall consist of the following:

- **"SW"** designation shall be used to identify all S&C 5 and 15 kV switches.
- **"TF"** designation shall be used to identify all transformers
- A four digit numbering or lettering scheme shall be used to number each switch and transformer. The numbering or lettering shall correspond with the location in reference to

a Building. See example below:

SW-0862-3 **SW** designates this as a 5 and 15 kV switch
0862 designates this switch is located adjacent to building 862
-3 designates this switch is the 3rd of several switches located adjacent to building 862.

TF-0862-3 **TF** designates this is a transformer
0862 designates this transformer is located adjacent to building 862.
-3 designates this transformer is the 3rd of several transformers located adjacent to building 862.

12.6.4 Medium Voltage Feeder Labeling

Label medium voltage feeder cables as noted in standard drawing WP5021STD, Example Feeder Labeling.

12.6.5 Underground Utility Labeling

For utilities installed in remote locations, specify underground utility markers per standard drawing WU5006STD, Utility Markers for Buried Pipe and Cable.

- End -